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RATE OF DECOMPOSITION OF KYANITE AT VARIOUS TEMPERATURES*

By Helen Blair Barlett

Abstract

The rate at which North Carolina kyanite of various grain sizes decomposes into mullite and glass in the range 1350° to 1600°C. is given. Kyanite from other sources is also discussed.

I. Introduction

A search of the literature has revealed that there is a limited amount of information available on the rate at which kyanite breaks down into mullite and siliceous glass when it is heated.

Greig[1] performed experiments on the three aluminum silicates, kyanite, andalusite, and sillimanite, that give an idea of the temperature range in which decomposition takes place as well as something of the rate as measured by the length of the mullite crystals developed in a certain period of time. Peck[2] also studied the decomposition characteristics of these minerals. In his work, temperatures were measured by pyrometric cones, but no data were given on the firing schedules. In neither work was sufficient information given to indicate how long kyanite of any particular grain size would need to be heated to effect complete decomposition. Pole and Moore[3] studied the expansion characteristics of kyanite, and their data may be used to infer the rate of decomposition at various temperatures up to 1349°C. and at a constant heating rate up to 1450°C. For these reasons, a study was undertaken to determine the rate at which kyanite decomposes to mullite and glass in the range of 1350° to 1600°C. and to learn the effect of grain size on this rate.

II. Raw Materials

North Carolina kyanite was used principally in this work. It was obtained as −28- +65-mesh material and had a high degree of freedom from contaminating minerals, quartz being the chief of these. A representative chemical analysis is ignition loss 0.13, SiO_2 41.52, Al_2O_3 57.98, Fe_2O_3 0.09, TiO_2 0.05, CaO 0.31, MgO 0.05, Na_2O 0.25, and K_2O 0.11%, a total of 100.49%.

Kyanite from the following other sources was also tested at the single temperature of 1410°C. to learn if the rate of inversion varies for different deposits: (1) clean blue crystals from Ticino, Switzerland, (2) blue-bladed crystals from Litchfield, Conn., (3) brown splintery material from India, (4) crystal from Black Mountain, N. C., and (5) blue-bladed crystalline aggregate of unknown origin.

III. Procedure

A platinum-wound resistance furnace equipped with a Pt-Pt 10% Rh thermocouple was used in this investigation, and temperatures were read on a Leeds-Northrup potentiometer. The charge was suspended by a fine platinum wire so as to hang close to the thermocouple junction.

At first, single crystal fragments were used. These were selected from the 28-mesh material that would go through the screen only when it was selectively oriented. Platinum wire, 0.005 inch in diameter, was looped around a fragment of the kyanite, which was then suspended by the wire in the platinum furnace, the latter having been previously heated to the temperature desired and adjusted to maintain that temperature for the length of time the sample was in it. The calcining period was timed with a stopwatch. At the end of the period, the sample was withdrawn, crushed, and examined microscopically to determine whether or not the kyanite had completely decomposed to mullite and glass. If it had not, the time was extended on the next run an appropriate amount, and another examination was made. This process was repeated until the minimum time required to effect decomposition at that particular temperature had been found. The temperature of the furnace was then changed and a similar determination was made. It was found that a smooth curve could be drawn through the points thus established.

The same procedure was followed in determining the rate of inversion for −325-mesh material and for that between 80- and 100-mesh screens. In these cases, of course, it was necessary to make a suitable container for the charge by fashioning a tiny basket from very thin (0.0004 in.) platinum foil. The basket was made to hold only as much kyanite as could be conveniently used to make up a single microscopic slide. A measuring spoon was carved from a soldering wire so that close to the same amount of kyanite would be introduced each time and the length of time required for bringing the complete charge up to the temperature of the furnace would be a constant factor. It should be understood that the values obtained in this study apply only for the system as set up for this experiment. It was found that even slight increases in the mass near the thermocouple junction, either of charge, platinum for carrying the charge, size of protecting refractory, or even the size of the bead forming the hot junction, would affect the results. In this case, the mass was kept down to a minimum so that the results would represent as nearly as possible the actual shortest periods required to effect a conversion of kyanite of the grain size indicated.

* Presented at the Forty-Second Annual Meeting, American Ceramic Society, Toronto, Canada, April 9, 1940 (White Wares Division). Received March 29, 1940.

[1] J. W. Greig, "Formation of Mullite from Cyanite, Andalusite, and Sillimanite," *Jour. Amer. Ceram. Soc.*, **8** [8] 465–84 (1925).

[2] A. B. Peck, "Changes in Andalusite, Cyanite, and Sillimanite at High Temperatures," *ibid.*, **8** [7] 407–29 (1925).

[3] G. R. Pole and D. G. Moore, "Expansion Characteristics of Kyanite and Kyanite-Clay Mixtures When Heated," *Bull. Amer. Ceram. Soc.*, **17** [9] 355–67 (1938).

Because the data obtained on the North Carolina kyanite did not agree with that published by Greig, kyanites from other localities were tested to see if the character of the reactions was independent of the type of kyanite used. All of the tests on these kyanites were made at the single temperature of 1410°C., which was the temperature at which Greig obtained complete decomposition in 15 minutes of a piece measuring 4 by 4 by 10 mm. The results in this work had indicated that it would require several times that long a period to effect decomposition of a crystal that size.

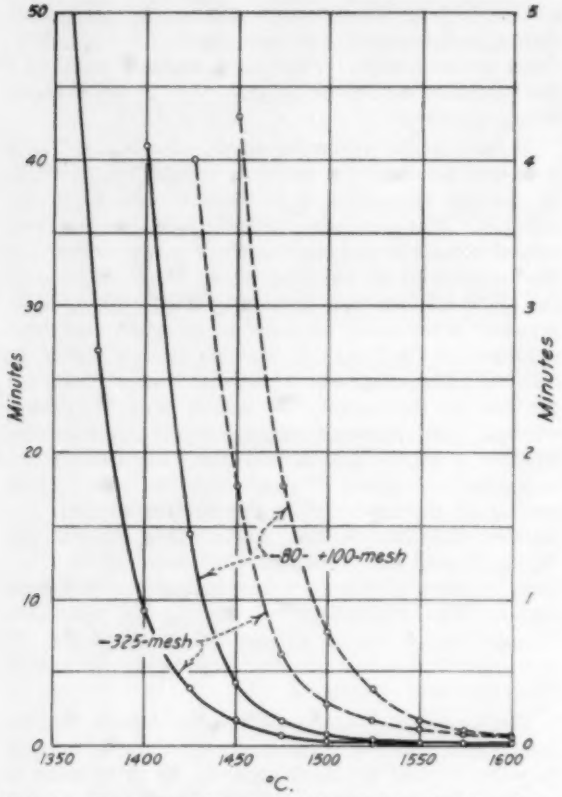

FIG. 1.—Decomposition rate of North Carolina kyanite; broken lines use right-hand ordinate.

IV. Results

(1) North Carolina Kyanite

The results are shown graphically in Fig. 1 made from the data in Table I.

Some of the data were plotted twice to show more accurately the values at the higher temperatures (note the broken curves); one curve indicates the −80-+100-mesh kyanite, the other the −325-mesh.

About twice as much time was required to decompose grains between 80- and 100-mesh as to decompose those passing a 325-mesh screen when the temperature was 1450°C. or higher. It is interesting to note how steeply the curve rises when the temperature is lower than 1475°C. The fact that at 1350°C. about seven hours were required to decompose 80-mesh material is not shown.

A comparison of these data with the expansion-rate curve reproduced from Pole and Moore[3] (Fig. 2) shows that they are in agreement. These writers state that at 1349°C. the expansion of −325-mesh kyanite is 87% complete in 50 minutes. Inasmuch as the expansion of kyanite is dependent on decomposition, it may be assumed that a large proportion of the grains has been converted to mullite and glass at this point. The slope of the expansion curve, however, indicates that more than 100 minutes would be necessary to bring the expansion up to 100%, when presumably no unconverted material would be left. In this study, 105 minutes were required at 1350°C. to effect complete conversion of all the grains passing a 325-mesh screen. The major part of the decomposition, however, had taken place in the early part of the period, and only the interiors of the larger grains resisted the change until the latter part of the heat treatment. As the kyanites used in these investigations were probably from the same source, little discrepancy in the two sets of data would be expected. Evidently the relation between the heat input of the

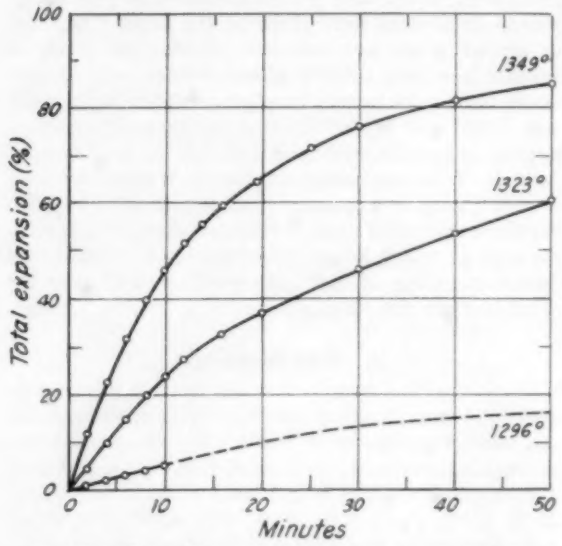

FIG. 2.—Expansion rate of kyanite at constant temperatures (after Pole and Moore). Grain size, −325-mesh; curves corrected for zero point.

TABLE I

TIME REQUIRED FOR DECOMPOSITION OF NORTH CAROLINA KYANITE

Temp. (°C.)	−80- +100-mesh (minutes)	−80- +100-mesh (seconds)	−325-mesh (minutes)	−325-mesh (seconds)
1600		4		3
1575		6		4
1550		10		6
1525		23		10
1500		43		16
1475	1	45		37
1450	4	15	1	45
1425	14	30	3	57
1400	41		9	15
1375			27	
1350	7 hours		1 hr. 45 min.	

TABLE II

DECOMPOSITION OF KYANITE AT 1410°C.

	Source	Cross section of fragments	Description	Time (minutes)	Reaction
(1)	Unknown	−325-mesh	Blue crystals	13½	Inversion barely completed
		4 x 4 mm.		15	" started but incomplete
(2)	India	5 x 5 mm.	Brown fibrous mass	15	" complete
(3)	Ogilby, Calif.	−80- + 100-mesh	Blue massive	15	" incomplete
		2 x 1 mm.		15	" "
(4)	Ticino, Switzerland	0.5 x 2 mm.	Transparent blue crystal	15	" "
		1.5 x 1.5 mm.		15	" "
(5)	Litchfield, Conn.	5 x 7 mm.	Blue massive	9	" nearly complete
		4 x 6 mm.		15	" complete
(6)	Black Mountain, N. C.	0.5 x 0.5 mm.	Blue massive bladed	15	" incomplete

furnace and the size of the kyanite charge was essentially the same in both investigations, thus accounting for the close agreement in results despite the differences in mass.

(2) Kyanites from Other Sources

In attempting to duplicate the results obtained by Greig, the kyanites from different sources were usually tested by the single-crystal method. The data are summarized in Table II. Because Greig used a piece of kyanite measuring 4 by 4 by 10 mm. and obtained complete decomposition at 1410°C. in 15 minutes, grains that were of the same order of magnitude were used in this work. In some cases, other sizes were also used in order to emphasize the results.

Table II shows that there is some disagreement among the data, and only two of the samples, those from India and Connecticut, yielded results in agreement with those of Greig. These discrepancies are apparently explained by the fact that the rate at which kyanite inverts to mullite and silica is determined less by the size of the original fragment than by the cross-sectional size of the fragments into which it shatters, by reason of the mechanical shock received in the crushing or grinding process or of the thermal shock received in the early part of the calcining process. The India kyanite was particularly fragile and readily broke down even in the fingers to very fine fibers. The Connecticut material seemed less easily broken down by mechanical means than some of the other kyanites, but apparently it was more disrupted by the thermal shock engendered by the introduction into the hot furnace. For these reasons, then, the two kyanites named were completely decomposed in the 15-minute period, whereas the others were only partially decomposed because they successfully resisted the mechanical and the thermal shock.

V. Conclusions

(1) North Carolina kyanite of the −80-mesh size requires from two seconds to seven hours to decompose to mullite and silica in the temperature range 1350° to 1600°C.

(2) The rate of inversion of kyanite at a given temperature varies with the degree of shattering produced in the fragments either by mechanical or thermal shock and, therefore, on the cross section of the individual cleavage fragments or fibers into which larger fragments may be reduced before the inversion temperature is reached.

AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN

PROPERTIES OF KAOLINITE AS A FUNCTION OF ITS PARTICLE SIZE*

By C. G. Harman and Felix Fraulini

Abstract

This investigation was undertaken to ascertain whether or not certain properties of kaolinite are definite functions of particle size. The studies were carried out on carefully fractionated, single-base kaolinite. The following properties of these fractions were measured: (*a*) base-exchange capacity, (*b*) permeability, (*c*) heat of wetting, (*d*) thermal conduct, and (*e*) drying shrinkage. Base-exchange capacity, heat of wetting, and drying shrinkage are not simple functions of the measured particle size of kaolinite because of the unpredictable physical characteristics and habits of the crystalline aggregates. The first three properties named are each linear functions of the other. These properties are independent of the physical groupings of the kaolinite crystals and therefore cannot be predicted from measured particle size except in the case of the finest fractions. Permeability is dependent both on apparent surface and true surface. Thermal-analysis curves may be useful as a rough guide to clay properties.

I. Introduction

The particle sizes of clays have been regarded as of basic importance for a couple of centuries. In 1770, Baumé[1] ascribed the plasticity of clays to their extremely fine state of subdivision and to their associated salts. The works of Way,[2] Schloesing,[3] Wheeler,[4] Cushman,[5] Ashley,[6] Keppeler,[7] and scores of others confirmed and expanded the postulates of Baumé. Many of these workers attempted to measure the "colloidal content" of clays by various means and to account for the behavior of clays on the basis of the results. The correlations were never exact, and few conclusions aside from those postulated by Baumé 150 years earlier could be drawn.

Studies of the nature of the "colloidal matter" itself proved to be a more fruitful field of investigation. Information was gradually accumulated and digested so that by 1933 Endell, Hofmann, and Wilm[8] were able to show more nearly the true relationships between the properties of ceramic clays. Several properties of natural kaolins and china clays have been correlated with base-exchange capacity by Klinefelter and co-workers.[9] Bray[10] measured the particle-size distribution of several clays. The plasticity of kaolin as a function of particle size was studied by Whittaker.[11]

Results of recent workers employing the modern technique show much better correlation of properties than those obtained from older "colloidal" methods, although exact correlations have not as yet been obtained.

The fact that the investigators did not use single-base,† pure clay minerals in their investigations may account for the lack of perfect correlation. These factors have been shown to be important by Kelley and Jenny,[12] Grim,[13] and others.

(1) Purpose of Investigation

Ceramists have long realized the need for a sound basis for blending and evaluating clays other than the laborious cut-and-try method. Particle-size data have often been suggested as a means of achieving this purpose; the literature, however, does not contain convincing evidence that it has been successful although yet greater possibilities are nearly always indicated.

This investigation was undertaken to obtain some properties of kaolin as it is influenced by particle size in an effort to ascertain whether or not these properties are definite functions of particle size. If correlation is possible, it should be obtained with clean fractions of pure, single-base kaolinite, thus eliminating the variables which have so often been neglected. It was also believed that the results possibly would indicate that other properties, which could be measured with greater ease and certainty, would yield information that would serve the same purpose as particle-size data.

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* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 18, 1939 (Materials and Equipment Division). Received February 19, 1940.

[1] A. Baumé, Memoire sur les Argilles, Paris (1770).

[2] T. J. Way, "Power of Soils to Absorb Manures," *Jour. Roy. Agr. Soc. Eng.*, **11**, 313–79 (1850); **13**, 123 (1852).

[3] T. Schloesing, "Constitution of the Clays," *Compt. rend.*, **79**, 376–80, 473–77 (1874).

[4] H. A. Wheeler, "Clay Deposits," *Mo. Geol. Surv.*, Vol. 11 (1896).

[5] A. S. Cushman, "Colloid Theory of Plasticity," *Trans. Amer. Ceram. Soc.*, **6**, 65–78 (1904).

[6] H. E. Ashley, "Colloid Matter of Clay and Its Measurement," *ibid.*, **11**, 530–95 (1909).

[7] G. Keppeler, "Further Contributions to the Knowledge of Clay," *Sprechsaal*, **46**, 445–47 (1913).

[8] K. Endell, U. Hofmann, and D. Wilm, "Nature of Ceramic Clays," *Ber. deut. keram. Ges.*, **14** [10] 407–38 (1933); *Ceram. Abs.*, **13** [4] 101 (1934).

[9] T. A. Klinefelter, W. W. Meyer, and E. J. Vachuska, "Properties of English China Clays," *Jour. Amer. Ceram. Soc.*, **16** [6] 269–76 (1933).

[10] R. H. Bray, "Significance of Particle Size Within the Clay Fraction," *ibid.*, **20** [8] 257–61 (1937).

[11] H. Whittaker, "Effect of Particle Size on Plasticity of Kaolinite," *ibid.*, **22** [1] 16–23 (1939).

† By single-base clays is meant those having a single species of ion adsorbed on the surface complex.

[12] W. P. Kelley and Hans Jenny, "Relation of Crystal Structure to Base Exchange and Its Bearing on Base Exchange in Soils," *Soil Sci.*, **41**, 376–82 (1936).

[13] R. E. Grim, "Relation of Composition to Properties of Clays," *Jour. Amer. Ceram. Soc.*, **22** [5] 141–51 (1939).

II. Experimental

(1) The Sample

The clay used in this investigation was a kaolin from Langley, South Carolina, that was selected because of its purity. X-ray diffraction patterns (Fig. 1) of the various fractions failed to show appreciable evidence of any mineral except kaolinite.‡

(2) Preparation of Sample

Hydrogen clay was prepared from the crude samples by leaching with 0.1 *N* HCl to remove soluble salts and to replace metallic bases. The clay was then leached with water to wash out the excess acid and dispersed with ammonia water (2 cc. of concentrated ammonium hydroxide (NH_4OH) to 1500 cc. of water).

These samples were divided into two particle-size fractions, one of which contained all particles larger than one micron in diameter and the other composed of particles smaller than 1 μ. This was done by sedimentation as follows:

The clay-water mixture was maintained at constant temperature, and the top 8 cc. was siphoned off at intervals of twenty-four hours. The ratio of the liquid decanted to that remaining was maintained at a maximum. After each decanting, water containing the required amount of NH_4OH was added to the sediment in the bottle and the contents were dispersed thoroughly by shaking. The process of decanting and redispersing was continued until the sediment was essentially free from particles finer than 1 μ. This procedure required seventy days.

The portion containing particles larger than 1 μ was divided into the following fractions by similar procedure: 2 to 4 μ, 5 to 10 μ, and 10 to 20 μ.

Particles finer than 1 μ were separated into the following size groups by means of a Sharples supercentrifuge: 1 to 0.5 μ, 0.5 to 0.25 μ, 0.25 to 0.1 μ, and 0.1 to 0.05 μ.

The formula used for the calculation of the feed of the suspension to the supercentrifuge and the speed of the supercentrifuge for separation of certain size particles was as follows:

$$t = \frac{\eta \log \frac{X_2}{X_1}}{3.81\,(d_1 - d)\,N^2 r^2}.$$

Wherein t = time.
η = viscosity of water at 25°C.
X_1 = radius of air core in bowl.
X_2 = radius of centrifuge bowl.
d_1 = density of clay.
d = density of water.
N = number of revolutions per second.
r = radius of particle.

The suspension was fed at the rate of 400 cc. per minute into the supercentrifuge which was being operated at a speed of 40,000 r.p.m. The suspension coming out at the top of the supercentrifuge contained particles smaller than 0.1 μ and was saved for further fractionation. The material in the bowl, about 80 grams, contained the particles larger than 0.1 μ still contaminated with particles smaller than 0.1 μ. This coarse material was placed in a small jar, ammonia water was added, and the material was blunged for approximately eight hours, or until the material was dispersed. It was then diluted to 40 to 60 liters. The amount of clay in the suspension was approximately 0.1% by weight of the clay-water mixture. The suspension was again fed at the same rate into the supercentrifuge, which was operated at the same speed. This was repeated until the liquid coming out of the supercentrifuge was clear. A thorough separation was thus obtained.

The same procedure was repeated for the separation of the particles varying in size from 1 to 0.1 μ. The feed of the suspension into the supercentrifuge and the speed of the supercentrifuge for each separation are shown in Table I.

TABLE I

CENTRIFUGE SPEED AND RATE OF FEED FOR PARTICLE SIZE SEPARATION

Fraction diam. (μ)	Rate of feed (cc./min.)	Speed (r.p.m.)
1 –0.5	720	12,000
0.5 –0.25	720	24,000
0.25–0.1	400	40,000
0.1 –0.05	125	40,000

As soon as the clay was fractionated, it was leached with 0.1 HCl to remove the NH_4 ions and washed with distilled water to remove the chlorides. The fractionation required about nine months to complete.

(3) Methods of Measuring Properties

(*A*) *Base-Exchange Capacity:* The base-exchange capacities were determined by the ammonia-distillation method. Ten grams of each clay fraction were leached with 400 to 500 cc. of neutral normal ammonium acetate, and the excess ammonium acetate was washed out with the same amount of neutral methyl alcohol. The NH_4 ions were displaced by leaching with 400 to 500 cc. of 0.1 *N* HCl. The filtrates were transferred to Kjeldahl flasks, 3 to 4 grams of NaOH pellets were added to the filtrates, and the ammonia was distilled into Erlenmeyer flasks containing 25 cc. of 0.1 *N* HCl. The excess hydrochloric acid was titrated with 0.1 *N* NaOH, the difference in the amount of HCl and NaOH used being the base-exchange capacity of the clay fraction.

(*B*) *Permeability:* A 10-gram sample was weighed to an accuracy of ±0.1 gram. The clay was deflocculated with 50 cc. of ammonia water, the sample was agitated for twelve hours, and then was flocculated by the addition of 0.1 *N* HCl. A 9-cm. Buchner funnel was prepared, using No. 50 Whatman filter paper, and made to set as nearly level as possible so as to drain into a flask within which a vacuum of 29 inches could be maintained. The suspension was carefully transferred to the funnel so that the same thickness of clay was deposited over the filtering area. After the clay layer had formed, normal pressure was restored and a graduated cylinder was placed inside the flask so that the funnel, when replaced, had its

‡ The diffraction patterns were examined by W. F. Bradley, Illinois State Geological Survey, who reported that weak lines corresponding to those of dickite were present in the fractions of 1 μ and finer.

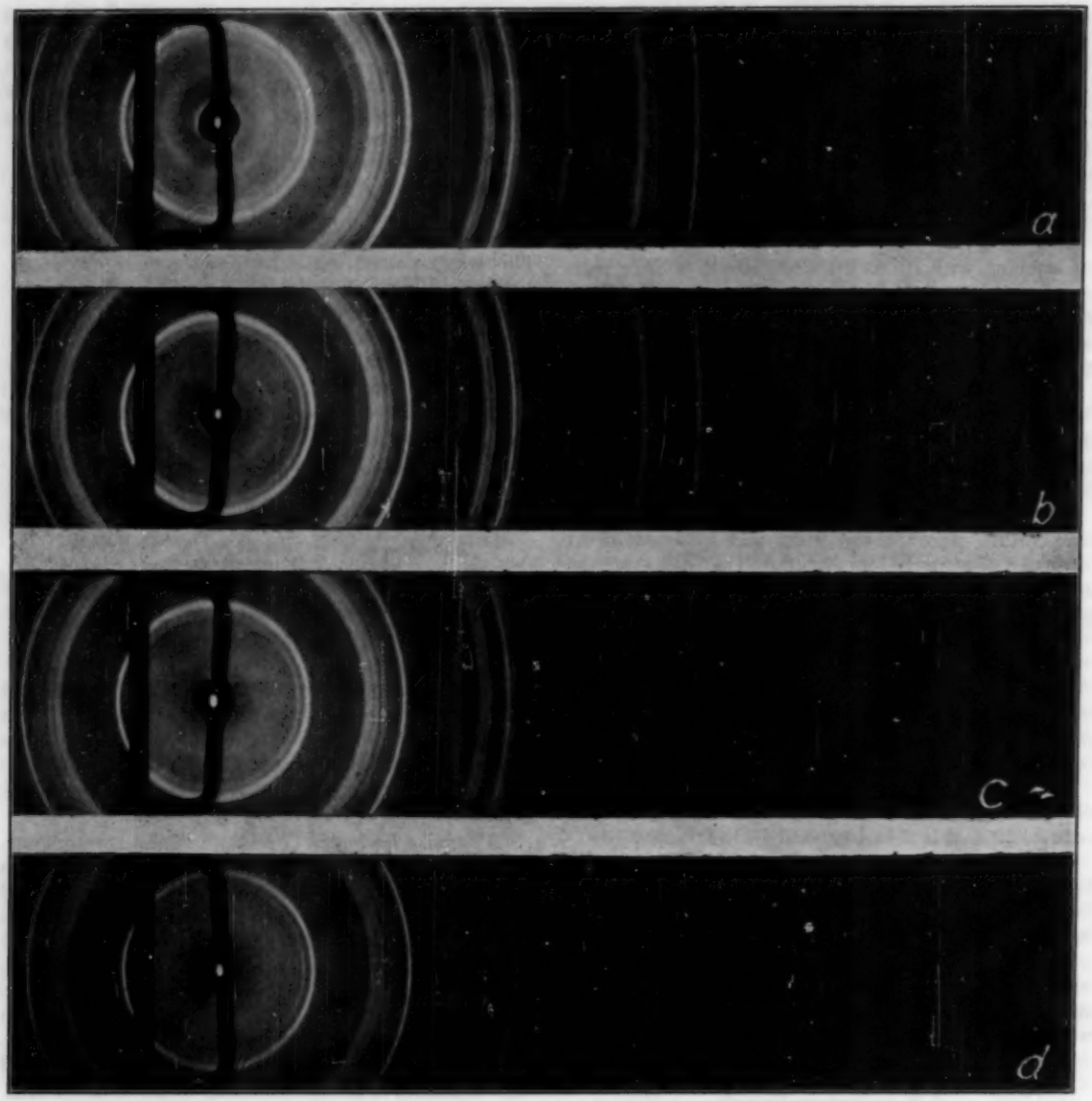

FIG. 1.—X-ray diffraction patterns of particle-size fractions (copper Kα); (*a*) unfractionated clay; (*b*) 10- to 20-μ fraction; (*c*) 5- to 10-μ fraction; (*d*) 2- to 4-μ fraction.

spout inside the graduated cylinder. The flask was again exhausted, and the time for 10 cc. of water to filter through the clay layer was noted. For the coarser fractions, 100 cc. of water were filtered through the clay to obtain greater accuracy in timing.

(*C*) *Heat of Wetting:* The heat of wetting was determined by a method devised by Janert.[14] The apparatus consisted of a Dewar flask which was suspended inside another larger Dewar flask. It was covered by a well-insulated lid, which was bored to accommodate a Beckman thermometer, a platinum-plated stirrer, and the sample bottle.

In making measurements, the calorimeter was charged with a quantity of water such that the volume of the water plus the volume of the sample was always 300 cc. The clay fractions were placed into the glass capsules, dried at 110°C. for 16 hours, weighed, and the glass caps were sealed with paraffin. The sample was then immersed in the calorimeter and allowed to stand in the flask overnight to attain thermal equilibrium. When ready to make the test, the water in the calorimeter was gently stirred, and the temperature and time were noted. The sample was then quickly dumped

[14] H. Janert, "Application of Heat-of-Wetting Measurements to Soil Research Problems," *Jour. Agr. Sci.*, **24**, 136–50 (1934); *Ceram. Abs.*, **14** [6] 149 (1935).

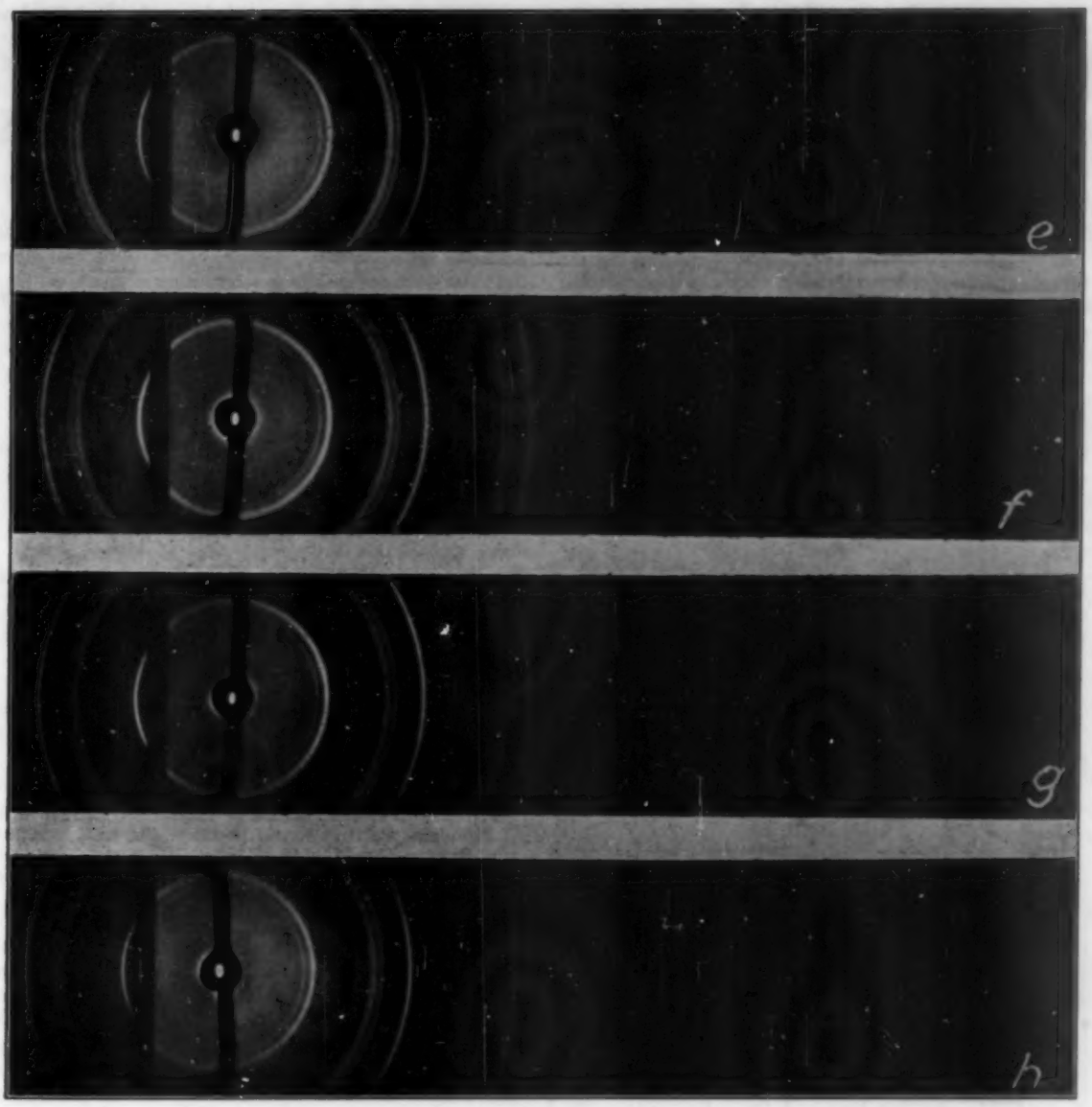

FIG. 1 (*continued*).—(*e*) 1- to 0.5-μ fraction; (*f*) 0.5- to 0.25-μ fraction; (*g*) 0.25- to 0.1-μ fraction; (*h*) 0.10- to 0.05-μ fraction.

into the calorimeter and, while constantly stirring, observations were made of temperature and time (Fig. 2). The heat of wetting was calculated from the temperature rise, the weight of sample, the weight of water, and the apparatus constant. The calorimeter was calibrated by the heat of solution of sodium carbonate.

(*D*) *Thermal Analysis:* The heat effects associated with the decomposition of the kaolinite molecule were studied by a comparison of the thermal curves of the sample and alpha-alumina. An Alundum crucible, 2 inches high and $^7/_8$ inch in diameter and divided into two compartments, held in one compartment the neutral body and in the other the 5-gram sample of clay. A differential Chromel-Alumel thermocouple was so placed that each of the branches was inserted through the bottom of the crucible compartments so that one junction was about midway in the mass of the neutral body and one in the clay sample. The heating rate of the furnace containing the samples was 6°C. per minute.

(*E*) *Linear Drying Shrinkage:* Bars $^1/_2$ inch in diameter and $3^1/_2$ inches long were made of each fraction. They were allowed to dry in air for ten hours and then dried at 110°C. for five hours. The shrinkage was determined by measuring the distance between reference marks before and after drying.

III. Results and Conclusions

Particle size is of interest chiefly because it affords a possible means to estimate surface effects. The surface effects of kaolinite are now known to result in the attraction of ions, which in turn are associated with a certain amount of water. The places of attraction of the positive ions are the exposed negative O and OH groups of the crystal lattice (Fig. 3). Kelley and Jenny[12] illustrate this as follows:

From the standpoint of H-ion displacement, two types of planes are of special significance. First, a plane of OH ions immediately on the exposed surface of the lattice package, which is arranged in the following manner:

H H H H H H H H
O O O O O O O O (hydroxyl plane)

Second, a subsurface OH plane, which is covered by a network of O ions, as illustrated by the following:

O O O O O O O O (oxygen plane)
H H H H H H (hydroxyl plane)
O O O O O O

The important feature of the second type of arrangement lies in the fact that the H ions of the OH plane are accessible through the meshes of the superimposed O network.

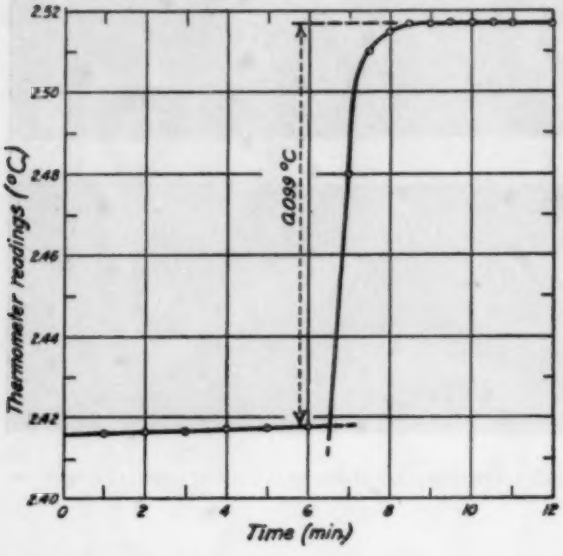

FIG. 2.—Heat of wetting of H kaolinite; weight of sample dried at 110°C., 33.0241 gm.; heat of wetting, 0.92 cal./gm.

By fine grinding, therefore increasing the number of OH groups exposed, they found that the base-exchange capacity of kaolinite was increased to a marked extent. The base-exchange capacity of kaolinite is a measure of the "effective surface" and thus affords a good means of checking the reliability of particle-size measurements as an index to clay properties.

Particle-size data, therefore, should be most useful in the form of surface area. The actual surface of the particles cannot be computed from these data, but it may be approximated by the following equation:

$$S = \frac{6}{\sigma D}.$$ *

Wherein S = total surface area of 1 gm. of particles
σ = density of particles.
D = diam. of particles.

This equation is based on the assumption that the particles are spherical. Simple calculations will show that the surfaces computed for other shapes are not radically different.

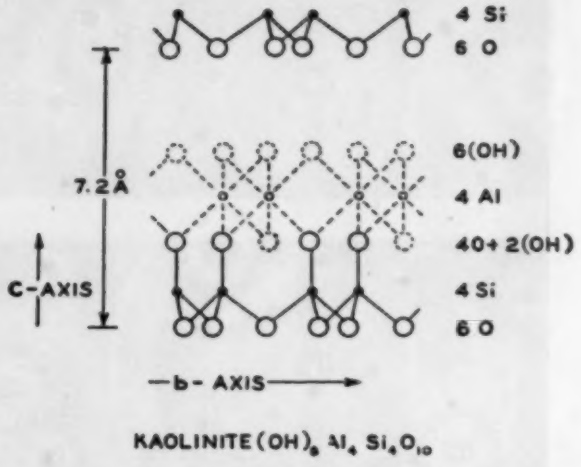

FIG. 3.—Crystal structure of kaolinite (modified after U. Hofmann, K. Endell, and D. Wilm, "Crystal Structure and Swelling of Montmorillonite," *Z. Krist.*, **86** [5–6] 340–48 (1933); *Ceram. Abs.*, **14** [4] 100 (1936)). (See Grim, p. 143 of footnote reference 13.)

The specific surfaces calculated from Stokes' law diameters of the various particle-size fractions are shown in column (2), Table II. The relation between these surfaces and base-exchange capacities is shown in Fig. 4. The coarser particles have abnormally high base-exchange capacities. This is attributed to the well-known habit of kaolinite crystals of growing in clusters or "books" which largely compose the coarser fractions. There are, of course, deep corrugations or interstices between the individual crystals in a single cluster, which greatly increases the surface over that computed for its over-all dimensions. The finer fractions approach individual crystals, whereas the finest fractions may contain cleavage flakes. The X-ray

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* Surface of each particle = πD^2.
Total surface in 1 gm. of particles = S.

$$S = (\pi D^2)N.$$

Wherein N = No. of particles/gm.
1 gm. = vol. of each particle × density × No. of particles.
$= V\sigma N.$

$$N = \frac{6}{\pi D^3 \sigma}. \qquad S = \frac{6}{D\sigma}.$$

patterns (Fig. 1) indicate surprisingly little difference in the size of the crystals in the different fractions. The patterns do not vary a great deal with the different particle-size fractions, presumably because the coarser fractions are composed of crystalline aggregates; the fine fractions on drying form oriented crystal-like groups.

TABLE II

COMPARISON OF PROPERTIES OF KAOLINITE OF DIFFERENT PARTICLE SIZES

(1) Size fraction (diam. in μ); (2) specific surface (sq. m./gm.)*; (3) base-exchange capacity (m.e./100 gm.); (4) heat of wetting (cal./gm.); (5) linear drying shrinkage (% dry length); (6) permeability time (sec.) to leach 10 cc. water through clay layer.

(1)	(2)	(3)	(4)	(5)	(6)
10–20	0.15	2.40	0.95	1.45	2.70
5–10	0.30	2.60	0.99	1.89	4.40
2–4	0.74	3.58	1.15	2.19	15.0
1–0.5	3.00	3.76	1.38	2.35	200
0.5 –0.25	6.60	3.88	1.42	2.69	452
0.25–0.10	12.90	5.43	1.87	3.70	474
0.10–0.05	30.20	9.50	i.s.†	i.s.†	750‡

*Calculated from arithmetical avg. diam. of each fraction by $S = 2.26/D$.
† Insufficient sample for determination.
‡ Computed from data obtained from 5-gm. sample; 10 gm. used for all others.

The shape of the curve in Fig. 4, therefore, is not fixed for the given mineral, kaolinite, but it is dependent on the specific habit of the crystals. Although the curves for clays of different origin are similar, they would be expected to show considerable variations.

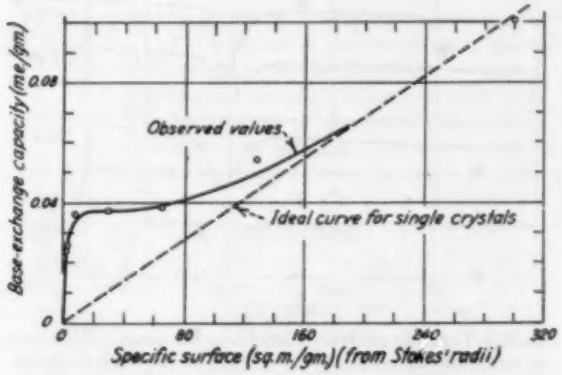

FIG. 4.—Relation between base-exchange capacity of kaolinite fractions and surface calculated from Stokes' law radii.

The broken line in Fig. 4 was drawn for the purpose of illustration and is not intended to represent the exact relation between base-exchange capacity and the surface area of single crystals.

The permeability of the fractions is shown in Fig. 5 plotted against base-exchange capacity and against surface. The base exchange-permeability curve shows the same characteristic high base-exchange capacity for coarse particles as brought out in Fig. 4. The permeability shows much better correlation with the specific surface, indicating that the over-all sizes of the particles are important in this case. Permeability depends on packing of the wet clay, which is determined by the sizes of the particles and by the associated water films. The permeability-specific surface curve is convex because of greater hydration per unit of over-all surface in the coarser fractions than there appears to be for the smaller single crystals.

The curves for drying shrinkage vs. specific surface and average particle diameter are given in Fig. 6. These curves show the same characteristics as other properties plotted in Figs. 4 and 5. The shrinkage of kaolinite is shown in Fig. 6 to be a linear function of base-exchange capacity. This seems to be a general relationship for kaolinite irrespective of its type of crystalline aggregation or of its origin.

Heat-of-wetting data have been used by Janert[14] to illustrate the mechanism of water adsorption. He reasoned that inasmuch as adsorbed ions remain partially ionized, even after adsorption, polar adsorption should be closely correlated with exchangeable bases. He concluded that adsorbed ions should bring about the association of water molecules in the same manner as free ions, differing only in the amount of association owing to the smaller field strengths of the adsorbed ions. Janert reports that 8.7% of the total heat of hydration of the hydrogen ions associated with clays at saturation is returned as heat of wetting. This is true irrespective of the state of dilution. Inasmuch as heats of solution vary with dilution, it would be expected that the heats of wetting would likewise be influenced. Unpublished data obtained in this laboratory have indicated this to be the case.

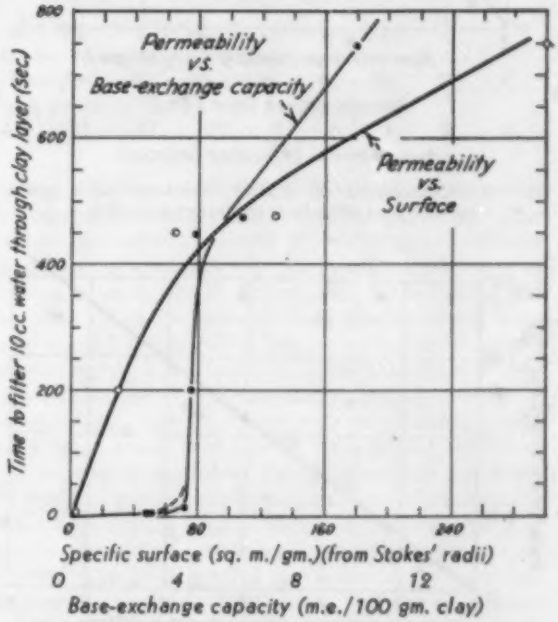

FIG. 5.—Permeability of kaolinite fractions as correlated with base-exchange capacity and with the surface of the particles.

Figure 7 shows that the heat of wetting of hydrogen-kaolinite is a linear function of base-exchange capacity. The proportionality factor, however, is different from that reported by Janert. It is significant because it indicates that function of the adsorbed ions in water-clay relationships.

The fractions were examined by thermal analysis to determine whether different ions would change the temperature at which the endothermic effect in the clay took place and also whether the particle size of the fraction would have any effect on the endothermic and exothermic reactions. In the course of examining numerous clays by routine methods for purposes other than those reported here, it appeared that the character of the thermal-analysis curves was in some measure at least associated with the particle size of the clays.

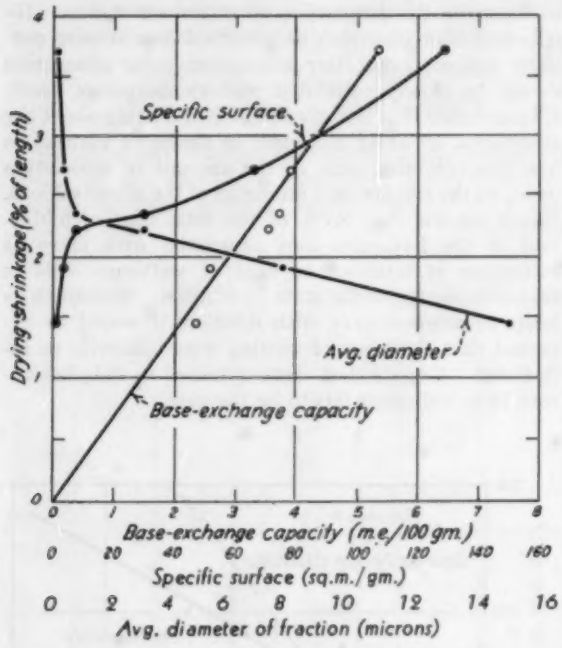

FIG. 6.—Correlation of drying shrinkage with gross surface and with base-exchange capacity.

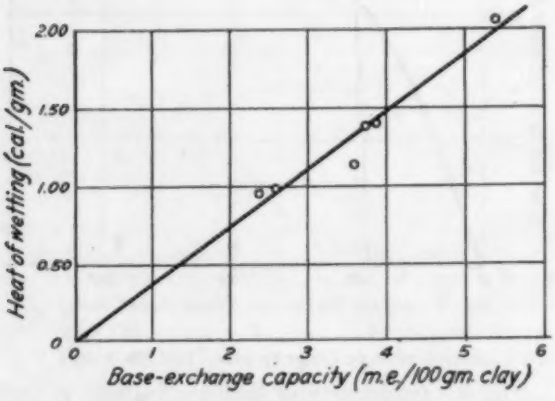

FIG. 7.—Heat of wetting and base-exchange capacity of kaolinite fractions.

The nature of the test is such that great precision could not be expected. The intensity of the heat effects would be dependent not only on the nature of the materials in question but also on the precise location of the thermocouple within the sample and on the efficiency with which the powder had been packed into the crucible. The tests were conducted in such manner as to minimize, insofar as possible, these extraneous effects.

Reference to Fig. 8 will show that there is a difference in the endothermic effects, both in magnitude of heat absorption and in a temperature range from the beginning to the end of the reaction. This difference, however, is small within the particle-size range investigated. Greater differences would be expected with the smaller fractions. Unfortunately, sufficient quantities of these samples were not available for the test.

A more reliable index, at least within this particle-size range, of the fineness of grain is found in the heat absorptions nearer 100°C. The cooling effect on this end of the curves may undoubtedly be considered as the reverse of the heat of wetting described. The more hygroscopic the clay, the greater this effect.

The endothermic reaction, near 600°C., was independent of the adsorbed cation. Heat absorption effects near 100°C., however, were characteristic of the exchangeable cation present. Ca clays have a higher heat of wetting than H clays, which is indicated by the curves in Fig. 9.

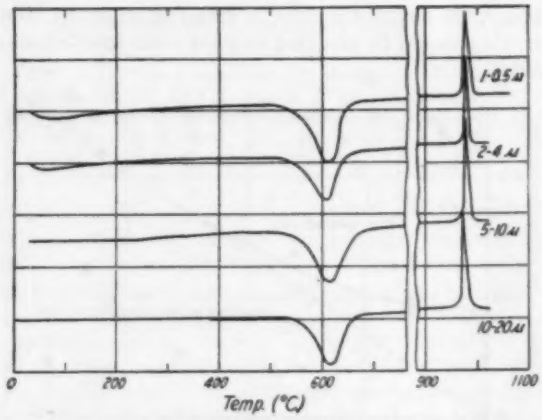

FIG. 8.—Thermal analysis of kaolinite fractions. Difference in temperature is approximately 25°C. for each division.

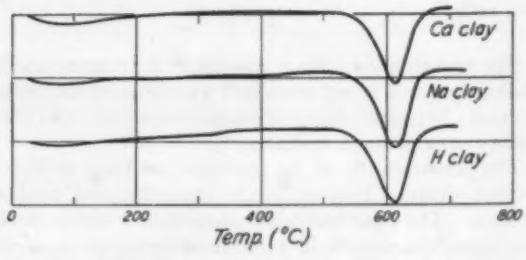

FIG. 9.—Thermal analysis of unib se clays. Difference in temperature is approximately 25°C. for each division.

The pertinent data regarding the critical points of the thermal-analysis curves are given in Table III. The temperatures of the endothermic peaks have been found in the course of other investigations carried on in this laboratory to depend somewhat on the nature of the crucible used.

TABLE III

THERMAL ANALYSIS OF CLAY FRACTIONS

Fraction diam. (μ)	Temp. of peaks (°C.)	
	Endothermic	Exothermic
10–20	617	973
5–10	615	977
2– 4	607	978
1–0.5	610	976
H clay	615	
Na clay	616	
Ca clay	614	

IV. Summary

The chief points brought out by these data are as follows:

(1) There is no fixed or simple relation between apparent surface of kaolinite, calculated from observed particle-size data, and true or effective surface, except in the finer fractions. (2) This is likewise true of the relation between the apparent surface and drying shrinkage, base-exchange capacity, and heat of wetting. (3) The effective surface of kaolins may be estimated better from base-exchange capacities than from particle size. (4) Permeability is dependent on both apparent and true surface. (5) Thermal analysis is a useful aid in classifying clays.

Acknowledgment

This investigation was a cooperative project of the Edward Orton, Jr., Ceramic Foundation and the Engineering Experiment Station of the University of Illinois, of which M. L. Enger, Dean, is director. Acknowledgment is made to C. W. Parmelee, Head of the Department of Ceramic Engineering, for advice in the selection of the project and assistance in its direction.

DEPARTMENT OF CERAMIC ENGINEERING
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

USE OF ALUMINUM METAL IN THE CERAMIC INDUSTRY I, PROPERTIES OF REFRACTORIES PRODUCED WITH MIXTURES OF ALUMINUM, FIRE CLAY, AND GROG *

BY H. G. SCHURECHT AND H. I. SEPHTON

ABSTRACT

The addition of aluminum metal powder to fire-clay–grog mixtures greatly increased the strength of the fired brick as a result of an aluminothermic reaction between the metal and the silica in the clay and grog. Because the reaction takes place at 930°C. and causes the temperature to rise rapidly, it is necessary to heat these refractories only to 930°C. to produce hard, well-fired brick. Such products have a high load-carrying capacity at furnace temperatures and also a fair spalling resistance.

I. Introduction

During a study of refractory coatings, produced by applying and firing aluminum metal[1] on fire-clay refractories, the coatings formed with 10% clay and 90% aluminum powder were found to be harder and darker in color than those containing equivalent amounts of aluminum oxide in place of the metal. An aluminothermic reaction developed at 800° to 950°C. between the metal and the clay, which resulted in the high strength of coatings containing the aluminum powder.

The results of these tests suggested the possibility of using this reaction as a new method for firing ceramic products, that is, to heat them to 800° to 950°C., which is a sufficient amount of heat to start the aluminothermic reaction, and to allow this heat together with certain reactions to produce a bond in the body. This method also affords a means of producing a refractory bond in many materials which otherwise would have to be fired to an excessive temperature. The heat is not conducted from the surface to the interior of the ware as in normal firing, but it travels uniformly throughout the body. The expansion of the aluminum during oxidation counteracts the shrinkage, and, by controlling the aluminum content, bodies may be produced which range from those that shrink considerably to those that expand to a marked extent after they are fired. Because the use of aluminum-metal powder in ceramic bodies appeared to afford a means of creating new and useful ceramic products as well as of improving others, patents have been applied for to cover the new discoveries in this field. This paper, the first of a series on the utility of aluminum in the ceramic industry, is limited to mixtures of aluminum powder, fire clay, and grog.

* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 19, 1939 (Refractories Division). Received February 16, 1940.

[1] H. G. Schurecht, "Reactions of Slag with Refractories: II, Refractory Coatings Produced with Metallic Aluminum," *Jour. Amer. Ceram. Soc.*, 22 [11] 384–88 (1939).

II. Materials*

The screen analysis of the aluminum powder used in this work is as follows: 100- to 150-mesh, 4.0%; 150- to 200-mesh, 6%; 200- to 325-mesh, 15%; and < 325-mesh, 75%.

The analysis of "peach-blow" fire clay is ignition loss 9.02%, SiO_2 60.67%, Al_2O_3 23.71%, Fe_2O_3 4.23%, TiO_2 2.06%, CaO 0.15%, MgO 0.09%, and K_2O + Na_2O 0.07%. The probable mineral composition of this clay is kaolinite 61.35%, quartzite 31.43%, hematite 4.22%, rutile 2.05%, calcite 0.27%, magnesite 0.19%, and feldspar 0.49%.

The grog had the following analysis: SiO_2 63.79%, Al_2O_3 26.6%, Fe_2O_3 3.80%, TiO_2 1.46%, CaO 0.20%, MgO 0.70%, and K_2O + Na_2O 3.11%. The screen analysis of the grog is > 14-mesh, 33.0%; 14- to 20-mesh, 15.0%; 20- to 28-mesh, 12.5%; 28- to 35-mesh, 8.2%; 35- to 48-mesh, 6.7%; 48- to 65-mesh, 6.4%; 65- to 100-mesh, 5.6%; 100- to 150-mesh, 4.7%; 150- to 200-mesh, 2.8%; and < 200-mesh, 5.1%.

III. Experimental Procedure

Twenty mixtures of fire clay, aluminum-metal powder, and grog were blended as shown in Table I and Fig. 1. The specimens were molded in the plastic state, and the properties determined were (1) drying shrinkage, (2) firing shrinkage, (3) absorption and porosity, (4) compressive strength, (5) thermal behavior, (6) load-carrying capacity at high temperatures, (7) resistance to spalling, and (8) reheat tests. Tests (1), (2), (3), (4), and (5) were conducted on cylinders, 1 by $1^1/_2$ inches in size, and tests (6), (7), and (8) were conducted on full-sized brick.

From the porosity and volume data of these specimens, the changes in volume of solids and of the pore space were also studied using the formula,

$$S = V - P. \qquad (1)$$

Wherein S = vol. of solids (% dry vol.).
V = total bulk vol. (% dry vol.).
P = vol. of pores (% dry vol.).

With the aid of this formula, calculations were determined on the changes in volume of solids in these mixtures after they were heated from 1000° to cone 8 (about 1260°C.). The term "solids" may be defined as the "volume of the briquettes excluding the pores."

To study the thermal behavior during heating, the specimens were fired in an electric tube furnace with one thermocouple inserted inside the specimen and another outside to measure the temperature changes of both the specimen and the furnace. When the aluminothermic reaction took place, the temperature inside the specimen rose rapidly above that of the furnace.

* Aluminum, No. 101 grade, from the Metals Disintegrating Co., Elizabeth, N. J.; peach-blow fire clay from M. D. Valentine and Bros., Woodbridge, N. J.; grog from Keystone brick, North American Refractories Co.

IV. Results

The results of the effect of aluminum powder on drying and firing shrinkage, absorption, and strength are given in Table I, and some of the results have been plotted in Figs. 1 to 4.

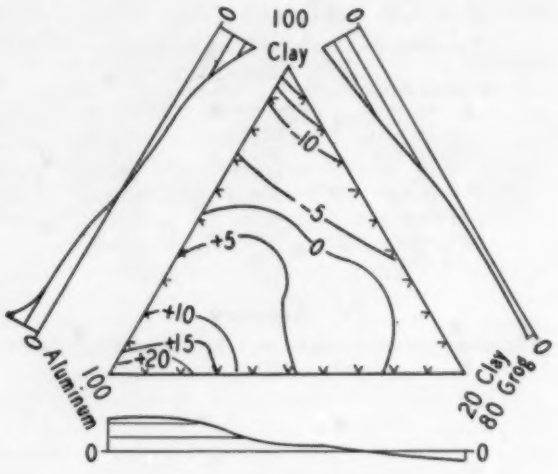

FIG. 1.—Expansions and shrinkages of aluminum, clay, and grog mixtures when fired to cone 8.

The thermal behavior of the specimens during heating is given in Table II.

Changes in solids and pore volumes are given in Table III and have been plotted in Fig. 5.

Brick that were prepared with a mixture of 48% fire

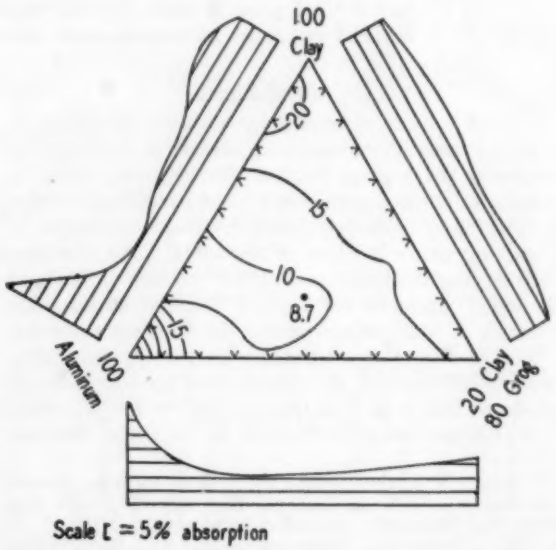

FIG. 2.—Absorptions of aluminum, clay, and grog mixtures when fired to cone 8.

TABLE I

PROPERTIES OF ALUMINUM, CLAY, AND GROG MIXTURES

Brick No.	Composition (%)			Drying*	Volume (%)†		Absorption (%)		Compressive strength (lb./in.²)	
	Fire clay	Aluminum powder	Grog		1000°C.	Cone 8	1000°C.	Cone 8	1000°C.	Cone 8
A	100			−23.2	−13.2	−29.8	28.4	16.8	2590	6510
B	90	10		− 7.8	− 8.5	−15.9	28.9	23.4	1390	3470
C	80	20		− 6.1	− 7.0	− 7.5	27.7	21.8	1140	3270
D	80	16	4	−12.7	− 6.5	− 9.5	24.8	20.5	1576	3910
E	60	40	0	−10.7	− 3.0	− 2.9	17.8	13.8	2190	5910
F	64	20	16	−18.6	− 4.1	− 4.5	19.2	16.1	2290	6710
G	68	0	32	−18.5	− 5.7	−10.6	23.2	19.3	1510	3540
H	40	60	0	− 6.1	2.3	4.6	14.0	9.1	2690	8420
I	44	40	16	− 3.6	4.5	8.3	14.5	11.1	2460	7410
J	48	20	32	−11.6	1.7	0.0	17.4	15.1	2190	5180
K	52	0	48	− 3.9	− 0.9	− 5.6	20.0	17.3	1260	2100
L	20	80	0	− 1.5	4.5	10.6	12.7	8.0	4940	9490+
M	24	60	16	− 4.6	4.5	7.6	10.2	8.9	5540	9980+
N	28	40	32	− 5.4	1.0	4.8	10.2	8.7	3460	9130
O	32	20	48	− 6.3	− 0.9	0.7	12.7	12.9	2570	6210
P	36	0	64	− 9.3	− 0.8	− 0.9	19.1	19.7	740	1300
Q	10	90	0	0.5	14.8	10.8	20.3	23.3	1760	2010
R	0	100	0	2.8	18.1	23.2	27.7	35.7	860	1080
S	4	80	16	− 0.8	24.6	24.1	14.4	12.7	2100	2610
T	8	60	32	1.5	8.4	7.5	7.8	10.2	5070	7900
U	12	40	48	2.0	2.9	3.8	7.8	12.1	3520	5150
V	16	20	64	− 0.9	2.4	− 0.7	11.3	13.4	2670	5720
W	20	0	80		− 1.3	− 5.2	15.9	16.3	910	2170

* Drying shrinkage indicated by minus (−); expansion by plus (+).
† Volume shrinkage indicated by minus (−); expansion by plus (+).

TABLE II

CRITICAL TEMPERATURES DURING ALUMINOTHERMIC REACTIONS IN ALUMINUM, CLAY, AND GROG MIXTURES

Column (1) brick No.; (2) maximum temperature reached in specimen as a result of exothermic reactions (°C.); (3) initial rise of temperature in specimen above normal (°C.); (4) temperature at which a sudden increase in temperature developed in specimen (°C.); and (5) temperature at which interior of specimen equaled that of furnace (°C.).

(1)	(2)	(3)	(4)	(5)
A	930			
B	1089	910	910	970
C	1163	896	910	950
D	1184	924	920	965
E	1488	874	920	920
F	1127	875	925	950
G	930			
H	1302	840	940	930
I	1374	928	960	950
J	1166	946	950	965
K	930			
L	1148	876	960	930
M	1272	899	930	940
N	1320	900	940	920
O	1107	896	930	930
P	930			
Q	1090	858	900	900
R	930			
S	1126	860	874	874
T	1308	926	970	960
U	1310	840	850	865
V	1216			1010
W	930			

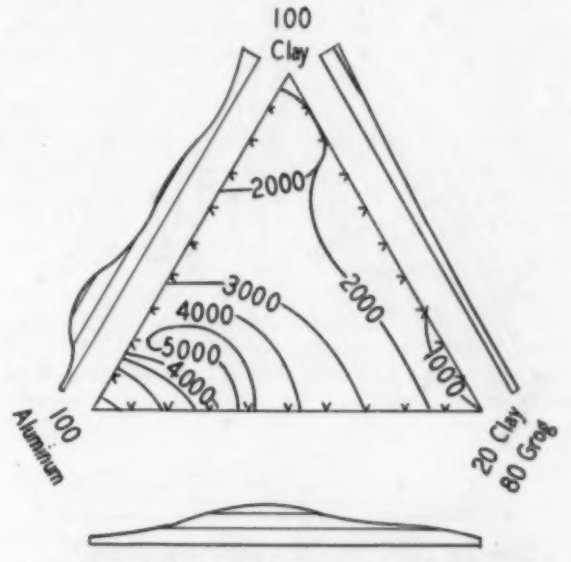

FIG. 3.—Strengths of aluminum, clay, and grog mixtures when fired to 1000°C.

clay, 20% aluminum powder, and 32% grog and fired to cone 8 withstood a load test of 25 lb. per sq. in. at 1500°C. for 1½ hours without deformation.

When similar brick were subjected to water-dip spalling tests from 1350°C. to room temperature, they lost from 5 to 47% by weight after twenty cycles. This loss does not indicate an extra high spalling resistance, but this property may be improved by closer control of size and grog proportioning and by substituting fired aluminum fire-clay brick for fire-clay brick grog.

Reheat tests conducted by heating cone 8 brick to cone 20 showed an expansion of 1.1% in length.

TABLE III

CHANGES IN SHRINKAGES, PORE SPACE, AND SOLIDS IN ALUMINUM, CLAY, AND GROG MIXTURES WHEN FIRED TO 1000°C. AND CONE 8

Brick No.	Fired vol. in terms of dry vol. (%)		Pore space in terms of dry vol. (%)		Solids (fired vol. (%) minus pore space)		Change in solid vol. from 1000°C. to cone 8
	1000°C.	Cone 8	1000°C.	Cone 8	1000°C.	Cone 8	
A	86.80	70.00	39.24	47.56	47.56	36.00	−11.56
B	91.44	74.10	39.65	32.62	51.79	41.48	−10.31
C	93.13	92.49	39.22	33.78	53.91	58.71	4.80
E	99.55	102.95	30.17	25.74	69.38	77.21	7.83
F	96.36	95.43	32.21	27.89	64.15	67.54	3.39
G	94.30	89.47	37.89	30.58	56.41	58.89	2.48
H	102.20	104.67	26.24	19.12	75.96	85.55	12.07
I	104.00	106.66	26.81	22.67	77.19	83.99	18.87
J	101.82	99.70	30.49	27.89	71.33	71.81	0.48
K	100.00	94.44	34.89	30.25	65.11	64.19	− 0.92
L	104.20	109.89	23.31	16.80	80.89	93.09	12.20
M	105.42	107.97	20.21	19.26	85.21	88.71	3.50
N	100.95	104.90	21.00	18.40	79.95	86.50	6.55
O	98.85	97.53	24.65	26.05	74.20	71.48	− 2.72
P	99.38	99.38	33.13	34.07	66.25	65.31	− 0.94
Q	114.73	110.76	32.95	28.31	81.78	82.45	0.67
R	123.83	121.62	47.27	61.49	76.56	60.13	−16.43
S	124.64	124.30	29.74	30.50	94.90	93.80	− 1.10
T	108.35	107.42	16.30	22.11	92.05	85.31	− 6.74
U	103.00	103.88	15.93	28.13	87.07	75.75	−11.32
V	102.45	99.01	23.08	27.17	79.37	71.84	− 7.53
W	100.00	94.81	29.18	28.57	70.82	66.24	− 4.58

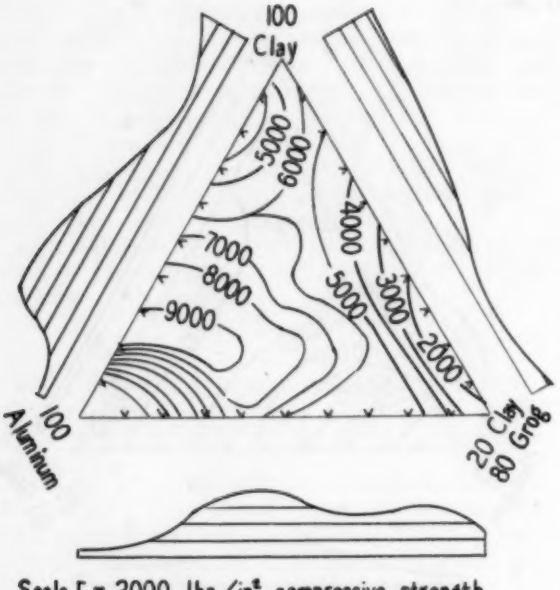

FIG. 4.—Strengths of aluminum, clay, and grog mixtures when fired to cone 8.

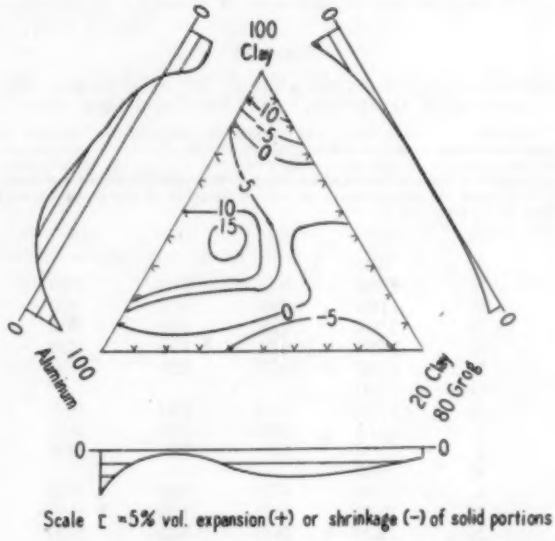

FIG. 5.—Expansions and shrinkages of the solid portions (volume minus pore space) of aluminum, clay, and grog mixtures in firing from 1000° to 1260°C. (cone 8).

V. Discussion of Results

(1) Drying Shrinkage

During the pugging of mixtures of aluminum powder, clay, and grog, heat was developed in some cases which was probably caused by a reaction between the aluminum metal and the water. This was accompanied by a slight expansion of some of the high-aluminum mixtures during drying (see Table I). The heat developed tended to speed up the drying rate as has been noted by De Bats.[2] Because this heat is developed within the body, it tends to promote drying from the inside as well as from the outside of the ware. In many of the bodies, however, no heat development was noticed.

(2) Firing Shrinkage

When the bodies were fired to 1000°C., the high-

[2] J. H. L. De Bats, U. S. Pat. 1,374,910 (April 19, 1921).

aluminum mixtures expanded, evidently caused by a partial oxidation of aluminum-silicon alloys (Table I). On firing to cone 8, further expansion was evident, resulting from a continued oxidation of these metals (Table I and Fig. 1). Bodies prepared with 50% aluminum and 50% clay, and also those with 20% aluminum, 50% clay, and 30% grog, remained practically constant in volume on being fired from 1000°C. to cone 8. The body with 50% aluminum is stronger than that with 20% aluminum, but it costs more.

(3) Absorption

When the specimens were fired to 1000°C., the absorption apparently was lowered by the addition of aluminum powder (Table I). Bodies with 8 to 12% clay, 40 to 60% aluminum powder, and 32 to 48% grog are among those that developed the lowest absorption at this temperature. When the bodies were fired to cone 8, some of them became more porous, whereas others grew more dense. The increase in porosity may have been due to a bulk volume expansion of the body, resulting from further oxidation of the metal constituents. The reduction of the porosity may be caused by the combined effects of filling the pores from further oxidation of the metals and by the vitrification of the clay and grog constituents in the bodies where the bulk volume did not expand very much. Bodies with 20 to 28% fire clay, 40 to 80% aluminum, and 0 to 32% grog are among those which develop a minimum absorption at cone 8 (Fig. 2 and Table I).

(4) Compressive Strength

The strength of fire-clay–grog mixtures was increased by the introduction of aluminum-metal powder into the body (Figs. 3 and 4 and Table I). Maximum strength was obtained from a mixture composed of 24% fire clay, 60% aluminum, and 16% grog when it was fired to 1000°C. as well as to cone 8. The strength was increased more than 80% by firing from 1000°C. to cone 8. Probably this increase in strength is partially due to crystallization of compounds formed through the oxidation of aluminum-silicon alloys. The fine-grained character of the nascent oxides thus formed probably would facilitate this reaction between these oxides to develop a crystalline bond such as mullite.

(5) Thermal Behavior

The maximum temperature developed in the specimens as a result of the aluminothermic reactions becomes greater with an increase in the aluminum content (Table I). The maximum temperature was reached in a mixture composed of 60% fire clay and 40% aluminum powder. From the chemical analysis of the clay, it was calculated that 45 parts of aluminum powder are sufficient to react with all of the silica and other impurities in 100 parts of clay. Maximum heat, however, was first developed with a mixture composed of 66.7 parts of aluminum and 100 parts of clay. The additional aluminum over that which had been calculated as necessary to react with the clay probably represents aluminum that had become oxidized from the oxygen in the air before the aluminothermic reaction took place. To produce maximum effects, therefore, an excess of aluminum powder must be used to insure a sufficient amount of metal to react with all of the clay after a portion of it has oxidized before the aluminothermic reaction.

The maximum temperature reached in the small specimens as a result of the aluminothermic reaction was 1488°C. The temperature reached in full-sized brick in some cases was 400°C. higher than that obtained in the small specimens; this would make the maximum temperature about 1800°C. in full-sized brick.

The thermal behavior of pure clay, medium aluminum, and high-aluminum mixtures is shown in Table II. This reaction apparently was much more sluggish for the high-aluminum bodies than for the medium-aluminum mixtures.

The difference in rise of temperature in the furnace minus that in the specimens is also given in Table II, which permits a closer analysis of the critical thermal reactions in the mixtures during heating. Assuming that when the bodies containing aluminum rise in temperature more than those without aluminum, these data would indicate that the reaction started very slowly at 690°C. and reached a maximum when the furnace temperature became 940°C. Some of these changes may have been caused by a change in the heat conductivity of the body as a result of a larger metallic content in the specimens.

(6) Solids

The pore space and amount of solid in each of the bodies are shown in Table III. The volume of solids increases when it is heated from 1000°C. to cone 8 in the high-aluminum mixtures, whereas the opposite is true in the low-aluminum mixtures.

The change in volume of the solids caused by firing was greatest for a body prepared from a mixture of 44% fire clay, 40% aluminum powder, and 16% grog. This mixture probably contained the most metal after it was fired to 1000°C., and it therefore developed the maximum oxidation when the firing was continued to cone 8.

(7) Resistance to Load

The load-carrying capacity of one composition only was tested, and it withstood a pressure of 25 lb. per sq. in. for one and one-half hours at 1500°C. without deformation. These full-sized brick were prepared from a mixture of 48% fire clay, 20% aluminum, and 32% of 4- to 10-mesh fire-clay grog. Other compositions with higher aluminum content probably would have even higher load-carrying ability at high temperatures.

(8) Resistance to Spalling

Although the resistance to spalling of the full-sized brick was not especially good, this property of brick may be improved by closer control of the size and proportioning of grog. Substituting the aluminum–fire-

clay brick grog for the fire-clay brick grog probably would also improve its spalling resistance.

(9) Reheat Tests

The reheat tests showed an expansion of 1.1% after heating to cone 20. This expansion may be reduced by lowering the aluminum content.

VI. Summary

The data given in this report were obtained by means of cylindrical specimens, 1 inch in diameter and $1^1/_2$ inches high, except for the load, spalling, and reheat data which were obtained with full-sized brick.

(1) Plastic mixtures of aluminum powder, clay, and grog often develop heat with a slight expansion of the body during drying, thus counteracting shrinkage and facilitating drying.

(2) Bodies with more than 50% aluminum powder develop marked expansions when fired to 1000°C. and cone 8 (1260°C.).

(3) The volume of mixtures of 50% fire clay and 50% aluminum powder and mixtures of 50% fire clay, 30% grog, and 20% aluminum powder remains constant in firing.

(4) A minimum absorption at cone 8 is obtained with mixtures of 20 to 28% fire clay, 40 to 80% aluminum powder, and 0 to 32% grog.

(5) Bodies prepared from 24% fire clay, 60% aluminum powder, and 16% grog develop higher strength than the other mixtures when they are fired to 1000°C. as well as to cone 8.

(6) A temperature of 1800°C., owing to an aluminothermic reaction, is developed in a full-sized brick composed of 40% aluminum and 60% fire clay when it is heated to 930°C.

(7) The aluminum metal powder probably starts to oxidize slowly at 690°C., and the aluminothermic reaction takes place at 930°C. The rapid rise in temperature, owing to the aluminothermic reaction, is safely above the dehydration temperature of the clay and therefore takes place when the danger of "popping," which accompanies too rapid dehydration, has passed.

(8) Compositions that develop maximum heat do not necessarily develop maximum strength. Among the clay-aluminum mixtures, maximum strength was developed in a body composed of 20% fire clay and 80% aluminum powder, whereas maximum heat was developed in a body composed of 60% fire clay and 40% aluminum.

(9) The metallic portion of the specimens being fired continues to oxidize, which causes an increase in the volume of the solids and oftentimes a further decrease in absorption.

(10) Brick prepared from a mixture of 48% fire clay, 20% aluminum, and 32% grog withstand a load of 25 lb. per sq. in. at 1500°C. for $1^1/_2$ hours without deformation.

(11) The resistance to spalling of similar brick has proved to be only fair as they lost 5 to 47% after twenty dips from 1350°C. to water.

(12) Reheat tests on the brick show an expansion of 1.1% on being heated to cone 20 (1530°C.).

Acknowledgment

The writers wish to acknowledge their indebtedness to J. F. McMahon and C. Major Lampman for conducting a portion of the laboratory work and to M. E. Holmes for suggestive interest in this work.

Ceramic Experiment Station
New York State College of Ceramics
Alfred, New York

STUDY OF THE REFRACTORY PROPERTIES OF TOPAZ*

By R. S. Bradley, F. W. Schroeder, and W. D. Keller†

Abstract

The effect of heat treatments on the chemical, physical, and mineralogical properties of topaz is described. The samples were obtained from a deposit of potential commercial importance. Brick made from calcined and uncalcined topaz were tested according to standard A.S.T.M. test methods, and the results are presented.

I. Introduction

Although topaz has long been considered a rather scarce semiprecious-to-precious gem mineral, a deposit, pure and large enough to be a potential source of raw material for the manufacture of refractories and known as the Brewer deposit, was described by Pardee, Glass, and Stevens in 1937.[1]

This mineral possesses properties and a chemical composition which are unique. The chemical formula is $[Al(F,OH)]_2SiO_4$ or $[Al(F,OH)_2]AlSiO_4$. Fluorine and hydroxyl water are isomorphous and are variable in relation to each other. Apparently topaz furnishes its own mineralizer, raises itself in refractory value through heating, and changes in chemical and mineral composition during heating toward a compound having high stability against glass or silicate slag.

Topaz has a hardness of 7 in Mohs' scale. It may be colorless, yellowish, greenish, bluish, or reddish. It crystallizes in the orthorhombic system and is therefore optically biaxial. The optical constants vary somewhat with the relative amounts of fluorine and water present, but those determined by Pardee[1] for the Brewer topaz are $\alpha = 1.629$, $\beta = 1.631$, $\gamma = 1.638$, $B = 0.009$, $2V = 48°$. The specific gravity is 3.509 within the range of 3.5 to 3.6, as shown in the Dana-Ford Textbook of Mineralogy.

Topaz commonly originates from the hot waters, vapors, and gases given off in the late stages of crystallization of a siliceous igneous rock magma. It may occur in veins or cavities within granite or rhyolite, in the surrounding country rock as in schists or gneisses, or in pegmatites and ore veins. Pardee believes that the Brewer deposit originated as a replacement of the original rock by topaz and other minerals brought in by magmatic solution.

II. Refractory Properties of Topaz

Topaz has possibilities as an excellent refractory raw material for several reasons.

(1) It is an aluminosilicate, high in alumina, combined with two volatile substances, fluorine and water. Firing during the manufacturing process will drive off the volatiles and leave a nearly pure aluminosilicate which may be expected to come to equilibrium as indicated by the equilibrium diagram for the system Al_2O_3–SiO_2; that is, the mineral, mullite, will be developed, with the excess silica going to glass or to a high-temperature form of silica.

(2) The high purity of the Brewer deposit and its freedom from fluxing alkalis or other metallic elements make it noteworthy.

(3) Perhaps no other pair of hyperfusibles could be chosen that would be so potent in catalyzing the formation of stable mullite as fluorine and water, both of which are found in topaz. In view of the intimacy of mixture, it is reasonable to expect the mineralizers to function most effectively.

(4) The mineralizers, fluorine and water, will remove part of the silica by volatilization and cause the composition of the remainder to approach that of mullite.

(5) The exceedingly small grain size of the topaz in this deposit is an important advantage. The fineness of the particle favors rapid and complete inversion to a form stable under the new temperature. The interlocking intergrowth of the grains makes for a strongly knitted, finished product.

III. Description of the Deposit

The Brewer deposit takes its name from the property on which it occurs, located about one mile northwest of Jefferson, Chesterfield County, South Carolina. Gold was formerly mined on the Brewer property and various prospect holes, open pits, and quarries that were dug during the gold-mining period have exposed enough topaz to give a fair idea of its extent. The country rock is a quartz-sericite schist in which the topaz occurs in a vein or veinlike body.

Northwest of an old open pit or quarry, a topaz vein about 25 by 50 feet extends to an undetermined depth. A tunnel running northwest from the pit encountered topaz at a point about 150 feet below the surface of the ground. Depths of other exposures extend to 25 or 30 feet in gold placer holes. Although exact quantities of ore have not been blocked out, all indications point toward a large topaz deposit in the ground and adequate reserves for use for a number of years in the refractories industry.

In addition to the vein material, there is a large quantity of placer topaz in boulders up to twelve inches in size. The surface boulders are smooth, subrounded, hard, and unweathered or unaltered. Only slight penetration of cracks in the boulders by ground water

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† R. S. Bradley and F. W. Schroeder, A. P. Green Fire Brick Co., Mexico, Mo.; W. D. Keller, Geology Dept., University of Missouri, Columbia, Mo.

[1] J. T. Pardee, J. J. Glass, and R. E. Stevens, "Massive Low-Fluorine Topaz from Brewer Mine, South Carolina," *Amer. Mineralogist*, **22** [10] 1058–64 (1937).

has taken place and decomposition along them is negligible.

Most of the topaz found in this area is gray or mottled and streaked in shades of gray. It shows a conchoidal fracture with a waxy luster, but the fragments now loose on the surface of the ground have separated along joints leaving angular polyhedral blocks.

Quartz is associated with the topaz, and the two resemble each other so closely that differentiation cannot be made by casual observation. The higher specific gravity of the topaz, 3.5, as compared with that of quartz, 2.65, enables them to be separated during mining.

IV. Change in Optical Properties and Mineral Transformation by Heat

The firing behavior of the Brewer topaz was determined with placer-mine lumps, selected for uniformity, and calcined for five hours at 1000°, 1500°, 2000°, 2500°, 2700°, 2800°, 2900°, or 3000°F. The mineral transformations were followed by studying powder and thin sections of the various lumps under a petrographic microscope.

Even in thin section, the unfired topaz resembles chert (Fig. 1). The topaz occurs as a mosaic of intergrown and interlocking subrounded grains from about 0.0015 to 0.005 mm. in diameter and in occasional short stringers or slightly elongate aggregates that may contain grains of sizes up to 0.15 mm. at their centers. More than 90% of the material, however, occurs in the fine-grained, intergrown, granular form which is likewise characteristic of chert. The birefringence of these two minerals is also the same, 0.009, but the main index of refraction of the topaz aggregate is about 1.63; quartz (chert) has a mean index of about 1.55. A small amount of an undetermined high-index, yellow-to-brown, fine-grained, anisotropic mineral is scattered irregularly through the topaz.

Pardee[1] found pyrite, enargite, and gold in small quantities in the rock and noted that other metallic-ore minerals have been reported. None of these minerals was found in the material mined for refractory use.

The fine, interlocking grains of the raw topaz showed little change until it was calcined at 1500°F., at which temperature a slight cloudiness appeared and the principal index of refraction decreased to 1.622. The crystal lattice remains intact in some of the material, but often sufficient disruption has occurred to give undulatory extinction (Fig. 2).

In the calcination at 2000°F., maximum disruption

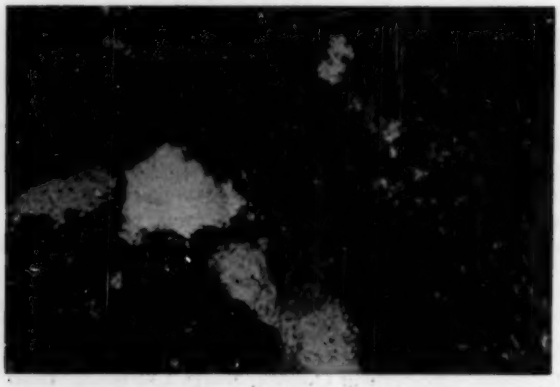

FIG. 1.—Raw topaz; crossed Nicols; original magnification 200×.

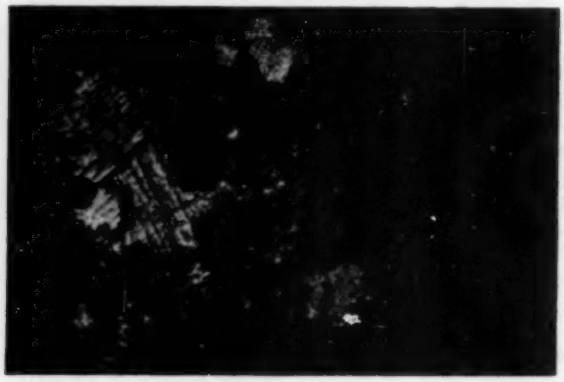

FIG. 3.—Topaz calcined at 2000°F. for five hours; crossed Nicols; original magnification 200×.

FIG. 2.—Topaz calcined at 1500°F. for five hours; crossed Nicols; original magnification 200×.

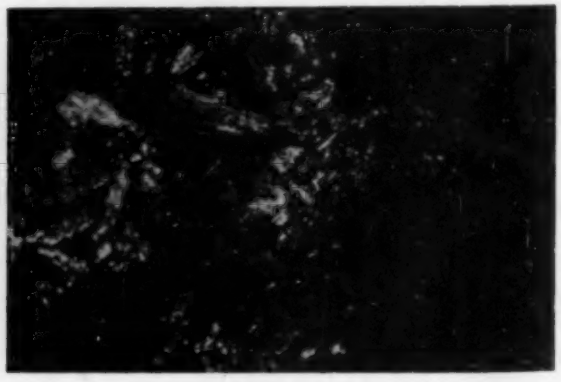

FIG. 4.—Topaz calcined at 2500°F. for five hours; crossed Nicols; original magnification 200×.

of the optical lattice occurred as shown by the low index of refraction, 1.607. The lumps are light gray to white. New cracks, opened during the heat treatment, traverse the lumps but are rarely persistent or deep enough to split them. A small amount of water-clear, lustrous, silica-glass scale covers part of the lump surface.

Three different types of material are distinguishable in the thin section (Fig. 3). One of these is the topaz originally present in the scattered groups of coarse grains, which is only slightly altered. Another is the previously mentioned coarse grains of topaz that have almost inverted to fairly coarse needles of mullite, averaging about 0.06 by 0.01 mm. in size.

The third type of material is the predominating, originally fine-grained and transparent (in thin section) groundmass aggregate. This is now clouded or darkened to a tan or light-brown color by what appears to be a fine dust. Much of this opacity may be due to the refraction or reflection of light from many submicroscopic cracks and pores opened during the loss of volatiles at this temperature. Furthermore, any silica that might be released during the inversion to mullite, which is probably beginning throughout the groundmass, will set up refraction boundaries and surfaces. The wide difference between the mean indices of mullite (1.640), topaz (1.630), and silica glass (1.462) indicates the extent to which the dark borders can develop. This cloudiness is largely dispelled at higher temperatures.

At 2500°F. (Fig. 4), mullite development is prominent. Some fairly large needles (0.07 mm.) have developed and most of the fine-grained groundmass has inverted, but this cannot be proved by direct observation. Chemical and physical tests confirm the belief that mullite inversion is essentially complete below 2500°F.; in fact, it appears to be complete at approximately 2300°F. The lumps of calcined topaz are chalky to light gray in color and are cut by cracks similar to the specimens heat-treated at 2000°F. The water-clear, lustrous silica glass has coated more parts of the surface than at the lower temperatures. The silica-glass coating was identified by its index of refraction.

The topaz heated to 2700°F. (Fig. 5) and 2800°F. (Fig. 6) shows progressively larger mullite needles, and needles 0.01 to 0.015 mm. in length are quite common. The cloudiness of the groundmass begins to disappear at 2700°F. and is much less evident at 2800°F. This confirms the petrographic evidence that the inversion to mullite is complete at 2500°F. and that the crystals grow as the temperature increases.

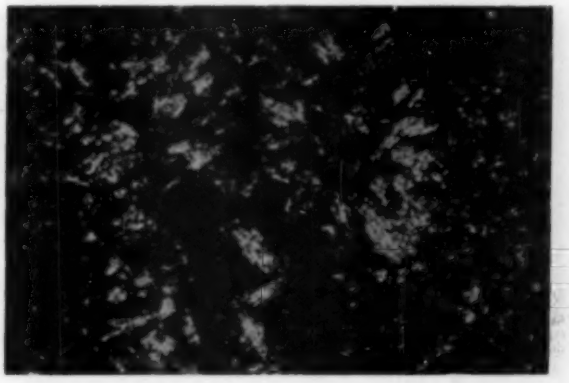

FIG. 5.—Topaz calcined at 2700°F. for five hours; crossed Nicols; original magnification 200×.

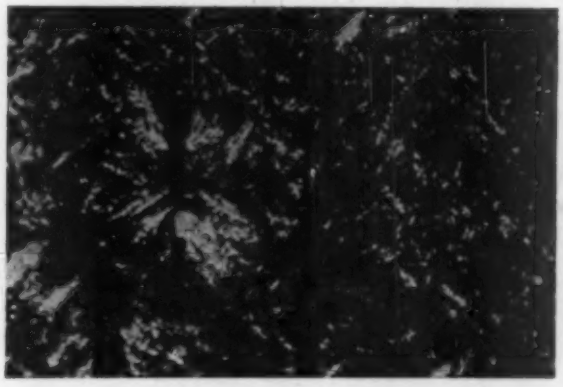

FIG. 7.—Topaz calcined at 2900°F. for five hours; crossed Nicols; original magnification 200×.

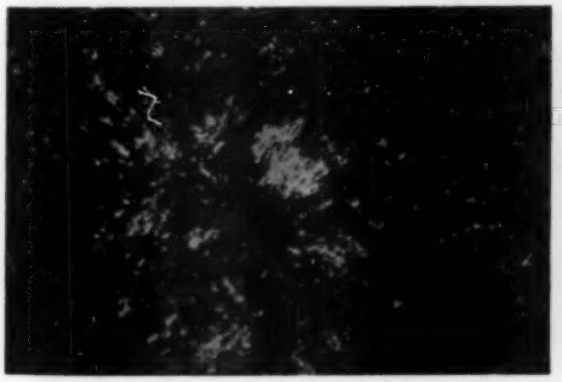

FIG. 6.—Topaz calcined at 2800°F. for five hours; crossed Nicols; original magnification 200×.

FIG. 8.—Topaz calcined at 3000°F. for five hours; crossed Nicols; original magnification 200×.

At 2900°F. (Fig. 7) and 3000°F. (Fig. 8), topaz seems to be at equilibrium as far as mineral development is concerned. The fine, small mullite needles have recrystallized to a larger average size, and the originally coarser ones appear to have remained constant. A more homogeneous network of interlacing crystals has developed. Impurities either have been lost in part or minimized in apparent quantity by segregation into scanty fine grains fairly evenly scattered. The mullite crystals are nearly transparent in the thin section.

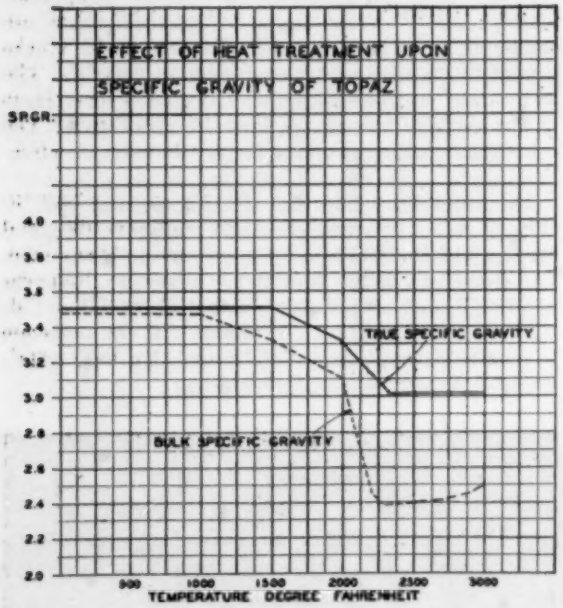

FIG. 9.—Effect of heat treatment on specific gravity of topaz.

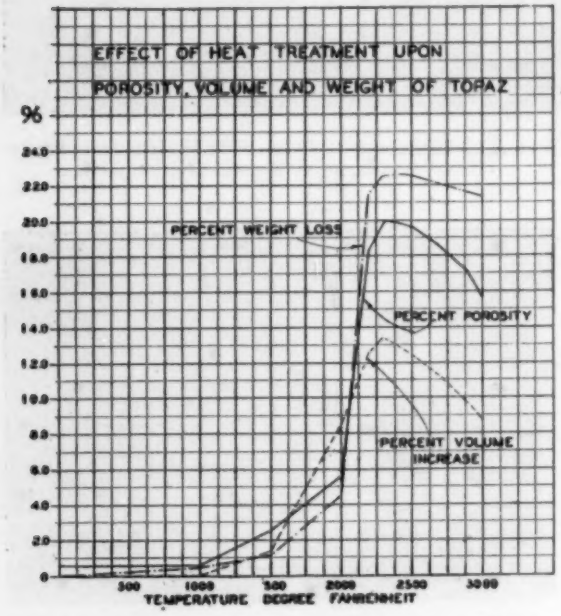

FIG. 10.—Effect of heat treatment on porosity, volume, and weight of topaz.

V. Change in Physical Properties by Heat

In addition to the petrographic studies described, the calcined lumps of topaz were also tested for changes in bulk and true specific gravity, porosity, volume, and weight. Upon charting the results of these determinations, it was obvious that important changes were taking place in the temperature range of 2000° to 2500°F. Additional lumps of raw topaz, therefore, were calcined for five hours at 2200° and 2300°F., and the test determinations were made on these samples. Figure 9 is a chart of the results of these determinations, showing 2300°F. to be the critical temperature for a calcination time of five hours. It is not known whether this same result could be achieved by longer calcination at lower temperatures.

VI. Change in Chemical Composition by Heat

A chemical analysis of raw topaz from the deposit under discussion is given by Pardee,[1] as follows: SiO_2 33.00, Al_2O_3 56.76, Fe_2O_3 trace, H_2O 0.04, H_2O + 2.67, and F 13.23%, a total of 105.70%; minus O = F = 5.57, a total of 100.13%.

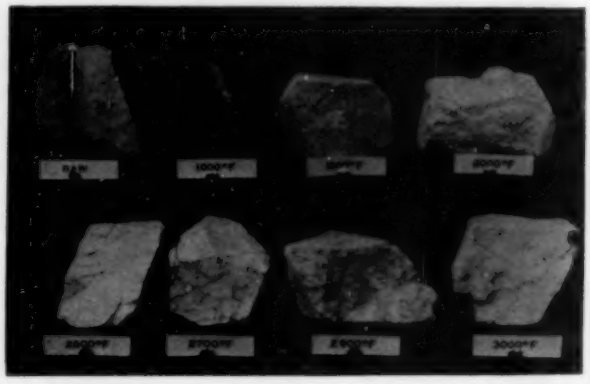

FIG. 11.—Changes in appearance of topaz with heat treatment.

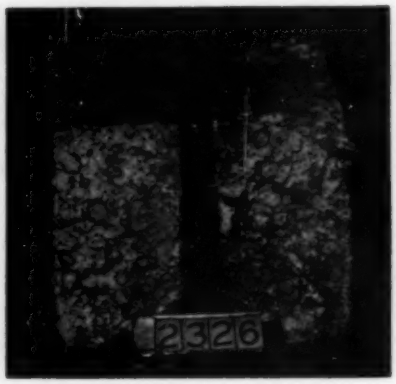

FIG. 12.—Scale which forms on raw topaz brick during firing.

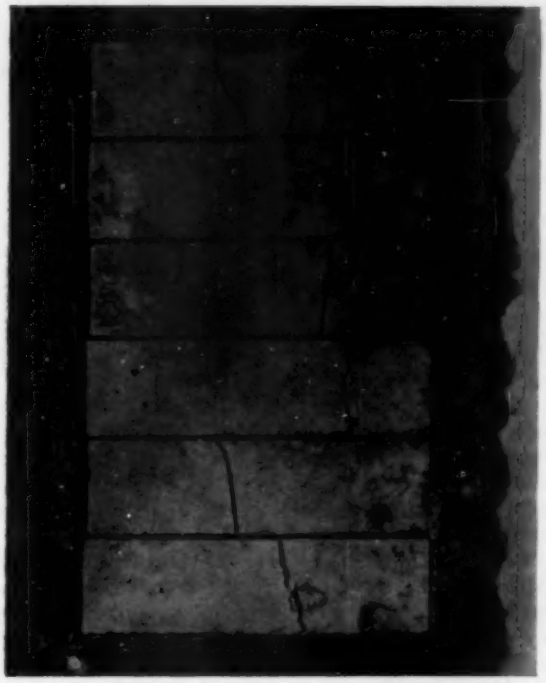

FIG. 13.—Panel of dry-press brick manufactured from raw topaz after preheat at 3000°F.

FIG. 14.—Panel of dry-press brick manufactured from raw topaz after preheat at 3000°F.

FIG. 15.—Panel of dry-press brick manufactured from precalcined topaz after preheat at 3000°F.

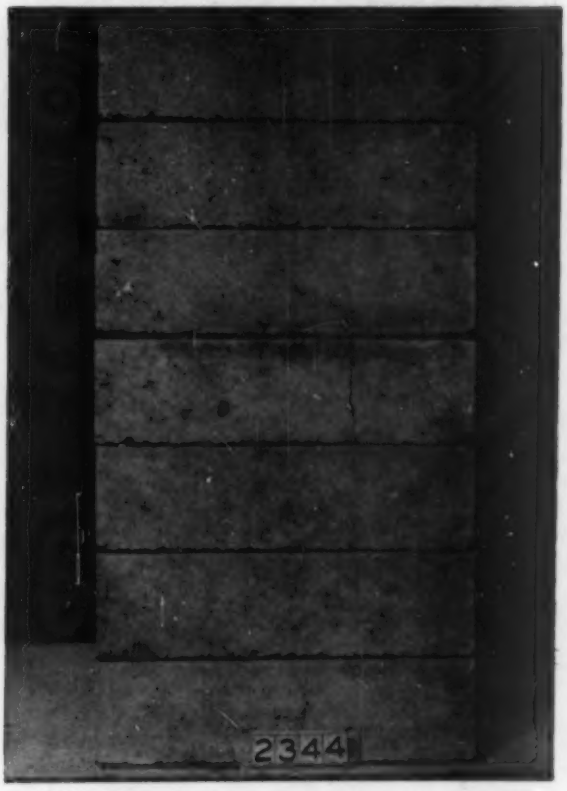

FIG. 16.—Panel of dry-press brick manufactured from precalcined topaz after panel spalling test.

TABLE I

PHYSICAL TESTS ON 9-INCH TOPAZ BRICK

	Dry press from raw topaz, 15% bond clay	Dry press from precalcined topaz, 15% bond clay
P.C.E. (Orton Standard cones) A.S.T.M. C24-35	Cone 38	Cone 38
Temperature equivalent (Bur. Stand. scale)	3335°F. (1835°C.)	3335°F. (1835°C.)
Reheat (permanent linear change) test A.S.T.M. C113-36 (5 hr. at 2912° F.); contraction (%)	0.87	0.47
Hot load test, A.S.T.M. C16-39T superduty (2642°F., 1½ hr., 25 lb. per sq. in.); compression (%)	0.25	1.56
Panel spalling test, A.S.T.M. C122-37 superduty (3000°F.); loss (%)	34.7	No loss
Apparent porosity, A.S.T.M. C20-39T (%)	24.2	26.6
Modulus of rupture, A.S.T.M. C133-39 (lb./sq. in.)	3810	1190

When this material is calcined at temperatures of 2500°F. or above, the volatiles, fluorine and water, are driven off and carry with them a certain amount of silica, thus increasing the alumina-silica ratio and the refractoriness. This could be predicted from the petrographic analysis already described.

Bowles[3] quotes an analysis of the raw topaz from the same deposit as 40% of silica and 50% of alumina and on the calcined product as 29% of silica and 71% of alumina. This is a considerably greater increase in the alumina-silica ratio than the writers have been able to find.

Analyses made by a commercial testing laboratory show the raw topaz to have 30% of silica and 53% of alumina, and another portion of the same sample, which had been calcined at a temperature of 2500°F., shows 31% of silica and 61% of alumina. As the removal of fluorine and water only would have raised the silica content to 36%, it is evident that approximately 5% of silica was removed with the volatiles. This is verified by chemical analysis of the nearly transparent scale which covered the surface of the calcined lumps. The scale was found to have a silica content in excess of 92%.

VII. Properties of Brick Manufactured from Raw and Calcined Topaz

A number of standard-size brick, 9 by 4½ by 2½ inches, were made from both raw and calcined topaz by the normal dry-press process, using 15% of a 28-mesh refractory bond clay in both cases.

The brick made from the raw topaz were fired in a tunnel kiln to approximately 2700°F. For the calcined topaz brick, the topaz was precalcined to approximately 2700°F., and the brick were fired in a tunnel kiln to 2500°F. The fired brick resulting from these two mixes presented quite a contrast in appearance. All of the raw topaz brick were covered with scale and blisters resulting from the elimination of silica during firing. This scale could be completely removed only by grinding, and even then the surface was irregular and pitted. There was no difficulty in manufacturing brick from raw topaz even though the firing behavior tests showed a permanent volume expansion of approximately 13%. The brick made from the precalcined topaz, on the contrary, had a pleasing appearance, creamy white in color and with few surface imperfections.

Standard A.S.T.M. tests were made on both types of brick. These tests included pyrometric cone equivalent, permanent linear change, hot load, panel spalling, apparent porosity, and modulus of rupture. In all cases, the test procedures specified for superduty fireclay brick were used. The results are shown in Table I.

It seems apparent that in massive topaz the refractories industry has gained a new or at least a heretofore unused raw material. Topaz was processed and manufactured into brick by conventional methods in this investigation. The results obtained are considered to be extremely encouraging for further development work.

A. P. GREEN FIRE BRICK COMPANY
MEXICO, MISSOURI

[3] Oliver Bowles, "Recent Progress in the Nonmetallics," *Mining and Met.*, 21, No. 398 (February, 1940).

RELATION OF ELECTRICAL CONDUCTIVITY TO CHEMICAL COMPOSITION OF GLASS*

By A. E. Badger and J. F. White

Abstract

The electrical conductivity of some glasses in the soda–lime–silica system was measured at 400°C. with an apparatus which is described. The specific resistance at this temperature ranged from 0.06 to 5.0 × 10^6 ohms per cc. Measurements were made on other glasses containing equivalent amounts of various oxides incorporated in a parent soda-lime-silica glass. It was found that an increase in resistance was produced by additions of MnO, ZnO, B_2O_3, Fe_2O_3, BaO, PbO, TiO_2, and K_2O, the resistances increasing in this order. A decreased resistance was produced by Na_2O, CaO, and Al_2O_3. Previously published data on the power factors of these glasses are reviewed.

I. Introduction

The purpose of this investigation was to study the electrical conductivity of glasses in the soda–lime–silica system and to determine the change in conductivity produced by equivalent molar additions of various oxides being incorporated in a soda-lime-silica glass.

The relation between electrical conductivity and temperature was not determined because all measurements were made at a constant temperature of 400°C., the precision being ±3% *ca.*

II. Experimental

(1) Range of Glass Compositions Studied

In the first series of glasses, weighed amounts of Na_2CO_3, $CaCO_3$, and SiO_2 were melted in the proportions necessary to cover the field of commercial glass compositions and the surrounding region. The chemical compositions of the glasses, as computed from the batches, are given in Table I, and Fig. 1 shows the positions of these glasses on the diagram of Morey and Bowen.[1]

In the second series, a base glass of the molecular composition 1.4 Na_2O, 0.9 CaO, and 6.0 SiO_2 (corresponding to 17.4% of Na_2O, 10.1% of CaO, and 72.5% of SiO_2) was chosen to which additions of various oxides were made on a gram-atomic basis in such manner that the same number of cations were added to the base glass. For example, 0.030 mol CaO was added to the base glass in one sample, whereas 0.015 mol Na_2O was added to another, and these additions contributed equal numbers of calcium or sodium atoms in the respective glasses. The oxides used and the compositions of the resulting glasses, as calculated from the batches, are given in Table II.

Table I

Glass Compositions in Soda–Lime–Silica–System (Series 1)

Sample No.	Na_2O (%)	CaO (%)	SiO_2 (%)	Specific resistance at 400°C. (× 10^{-6})
12	32	4	64	0.66
13	28	8	64	1.1
14	24	12	64	2.0
15	20	16	64	3.4
16	30	0	70	0.06
17	26	4	70	0.8
18	22	8	70	1.4
19	18	12	70	2.7
20	14	16	70	4.2
21	26	0	74	0.07
22	22	4	74	0.88
23	18	8	74	1.8
24	14	12	74	3.4
25	10	16	74	5.0
26	22	0	78	0.08
27	18	4	78	1.2
28	14	8	78	2.6
29	10	12	78	4.5

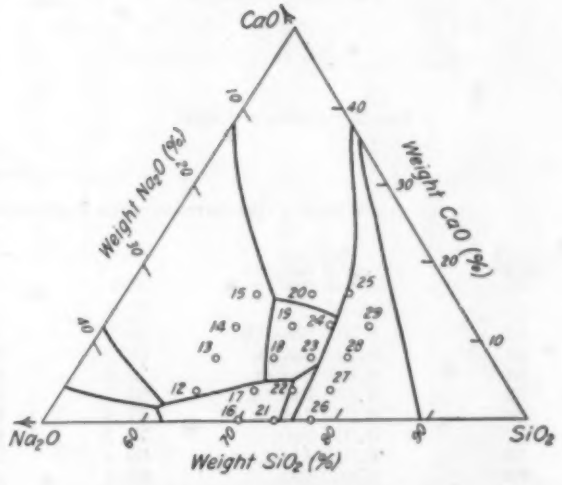

Fig. 1.—Chemical compositions of glasses superposed on Na_2O–CaO–SiO_2 equilibrium diagram of Morey and Bowen.[1]

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* Presented at the Forty-Second Annual Meeting, American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Received March 25, 1940.

Part of thesis submitted by J. F. White for the degree of Master of Science in Ceramic Engineering, University of Illinois. Appreciation is expressed for the advice offered during the course of the investigation by C. W. Parmelee, Head of the Department of Ceramic Engineering.

[1] G. W. Morey and N. L. Bowen, "Ternary System Sodium Metasilicate–Calcium Metasilicate–Silica," *Jour. Soc. Glass Tech.*, 9 [35] 226–64 (1925); *Ceram. Abs.*, 5 [2] 63 (1926).

(2) Preparation of Glass Samples

Both series of glasses were made by weighing the chemically pure materials on an analytical balance, mixing them thoroughly, and melting the batch in a platinum crucible. The glasses were ground in a steel mortar, passed over an electromagnet to remove the iron, and remelted. This process was repeated in order to produce homogeneous glasses.

The fused samples were ground to form specimens approximately 1 sq. cm. in area and from 2 to 3 mm. thick. These were plated with platinum to form surfaces for contact with the electrodes. The solution for plating the samples was prepared by dissolving $^1/_2$ gm. of platinum chloride in alcohol and diluting with 50 cc. of oil of lavender. The samples were heated to 450°C., leaving a layer of pure platinum metal on the glass. The edges of the samples were ground after plating to remove any platinum that had been deposited there, washed in alcohol, and tested. Their volumes were determined by the suspended-weight method using an analytical balance.

(3) Description of Apparatus

The furnace (Fig. 2) was designed with a large diameter to produce a more nearly uniform temperature in the sample. This was further provided for by the refractory support for the bottom electrode that extended up around the electrodes, forming a tube around the sample.

The furnace was wound with Chromel wire and insulated with Sil-O-Cel. The electrode leads were insulated with refractory tubing; the electrodes were silver plates. A blank run on the apparatus, with the electrode separated by an air gap equal to the sample thickness, indicated the resistance to be above 10^9 ohms.

The sample was placed on the bottom plate and the top plate was loaded to insure good contact. Figure 3 shows the method of testing the sample in detail, in which the sample, S, is between the electrode plates, P_1 and P_2, with the silver wire leads, L_1 and L_2, encased in the refractory insulation. The thermocouple, TC,

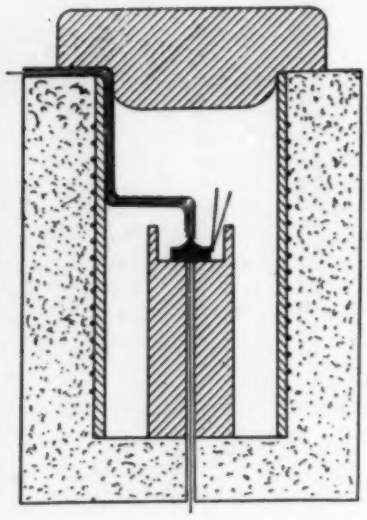

FIG. 2.—Furnace design.

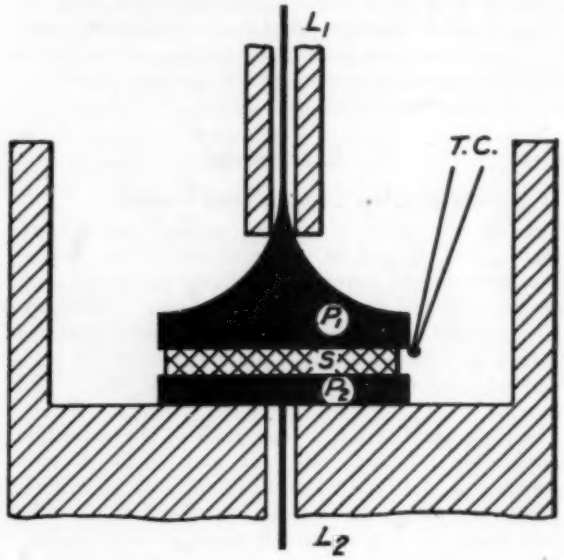

FIG. 3.—Method of testing sample.

TABLE II

GLASS COMPOSITIONS WITH EQUIVALENT ADDITIONS OF OXIDES (SERIES 2)

Sample No.	Substance added to base glass (mol)	Chemical composition (%)				Specific resistance at 400°C. (ohm $\times 10^{-6}$)
		SiO_2	Na_2O	CaO	Additional substance	
51	None	72.5	17.4	10.1	0	2.0
52	0.015 Na_2CO_3	70.6	16.9	9.8	2.7 Na_2O	1.9
53	0.015 K_2CO_3	69.6	16.7	9.6	4.1 K_2O	4.6
54	0.030 $CaCO_3$	69.0	16.6	9.6	4.8 CaO	1.6
55	0.030 $BaCO_3$	63.7	15.3	8.9	12.1 BaO	3.6
56	0.030 ZnO	67.6	16.2	9.4	6.8 ZnO	2.4
57	0.015 B_2O_3	70.3	16.9	9.7	3.1 B_2O_3	2.5
58	0.015 Al_2O_3	69.4	16.6	9.6	4.4 Al_2O_3	0.7
59	0.030 SiO_2	68.8	16.5	9.6	5.1 SiO_2	2.0
60	0.010 Pb_3O_4	60.4	14.5	8.4	16.7 PbO	4.2
61	0.015 Fe_2O_3	67.7	16.2	9.4	6.7 Fe_2O_3	3.0
62	0.030 MnO_2	67.7	16.3	9.4	6.6 Mn_2O_3	2.2
63	0.030 TiO_2	67.7	16.2	9.4	6.7 TiO_2	4.5

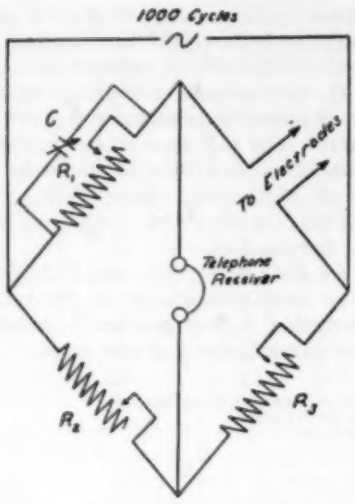

FIG. 4.—Method of measuring resistance.

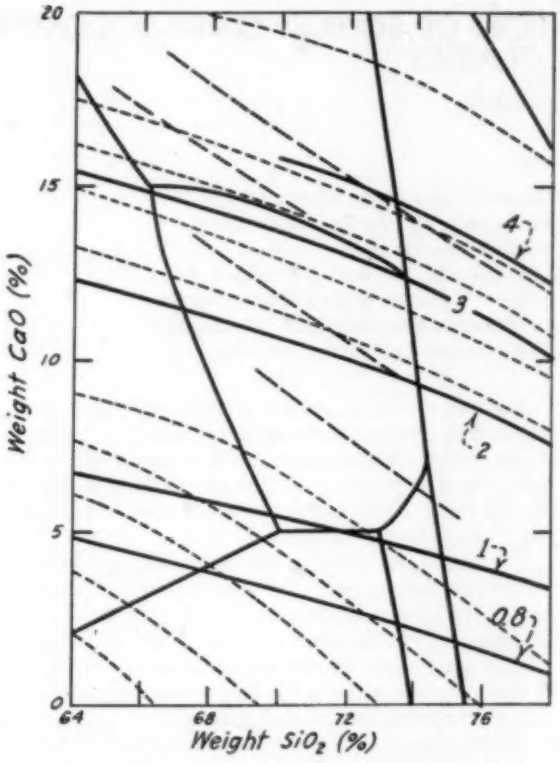

FIG. 5.—Lines of constant specific resistance of soda-lime-silica glasses at 400°C., superposed on a diagram of Morey[2]; values to be multiplied by 10^5. Dotted lines of equal power factors (at 100 kc. and 25°C.), reading from lower left to upper right, represent percentage power factors of 10, 5, 4, 3, 2, 1, 0.9, 0.8, 0.7, and 0.6, respectively (data of Thurnauer and Badger[3]). Lines shown by dashes give some of Stott's[4] results on viscosity measurements at 575°C. These lines represent equal viscosities, respectively, of 10^{10}, 10^{11}, 10^{12}, and 10^{13} poises. (The Na_2O content of glasses is obtained by subtracting CaO + SiO_2 from 100.)

(1940)

was placed as close to the sample as possible to insure a reliable temperature measurement.

The resistance was measured with a Wheatstone bridge (Fig. 4). The e.m.f. source was a tuning-fork oscillator,* operating at 6 volts and 1000 cycles. The resistances, R_1, R_2, and R_3, were a battery of radio resistors varying from 10^3 to 10^7 ohms. The capacity of the electrode plates was balanced out with a 500-micro-micro farad condenser, C. The current flow was measured with telephone receivers capable of detecting a difference of 1% in the resistance.

The samples were annealed in position in the furnace and then cooled to 400°C., at which temperature the resistance was measured. They were maintained at a constant temperature until the resistance was found to remain constant. Duplicate tests were run on most of the samples to verify the results.

III. Results and Conclusions

The results from the first series of glasses are given in Table I and are shown as a function of composition in Fig. 5, where lines, having the constant resistances of 0.8, 1, 2, 3, and 4 × 10^5 ohms at 400°C., are superposed on an equilibrium diagram of Morey.[2] Figure 5 also gives (in dotted lines) the power factors at 100 kc.

* Audio oscillator type No. 213 from General Radio Co., Cambridge, Mass.

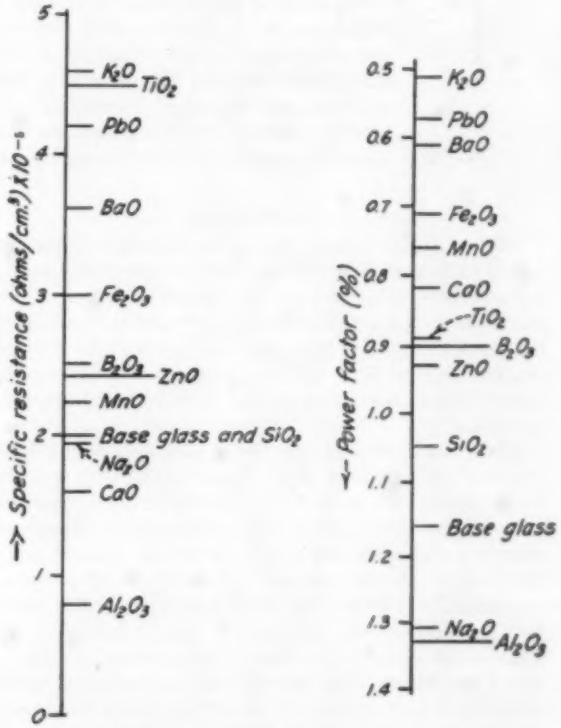

FIG. 6.—Effect on specific resistance (at 400°C.) and on the percentage power factor (at 25°C. and 100 kc.) of incorporating equivalent amounts of various oxides in a parent soda-lime-silica glass.[3]

and 25°C. of glasses in this part of the system.[3] The dotted lines, reading from lower left to upper right in the diagram, represent power factors of 10, 5, 4, 3, 2, 1, 0.9, 0.8, 0.7, and 0.6%, respectively. Also shown in dashed lines are the viscosities, measured at 575°C., adapted from Stott's data.[4] These viscosity lines represent equal viscosities, reading from bottom to top, of 10^{10}, 10^{11}, 10^{12}, and 10^{13} poises, respectively. Variations of these three properties with change in composition show similar trends, but there is no evidence of correlation with the equilibrium diagram.

The results of the second series of glasses, as given in Table II, are compared graphically in Fig. 6 with the results of power-factor measurements of Thurnauer and Badger.[3] The resistance of the parent soda-lime glass at 400°C. is seen to be increased by equivalent additions of MnO, ZnO, B_2O_3, Fe_2O_3, BaO, PbO, TiO_2, and K_2O, in that order, whereas Na_2O, CaO, and Al_2O_3 decreased it.

Except for CaO, MnO, SiO_2, and TiO_2, the results of power-factor measurements are in the reverse order, as expected, that is, high-resistance glasses generally possess low power factors and vice versa.

[3] G. W. Morey, "Interpretation of Phase Equilibrium Diagrams," *Glass Ind.*, **12** [4] 69–80 (1931); *Ceram. Abs.*, **10** [6] 458 (1931).

[3] H. Thurnauer and A. E. Badger, "Dielectric Loss of Glass at High Frequencies," *Jour. Amer. Ceram. Soc.*, **23** [1] 9–12 (1940).

[4] V. H. Stott, "Viscosity of Glass," *Jour. Soc. Glass Tech.*, **9** [35] 207–25 (1925); *Ceram. Abs.*, **5** [2] 47 (1926).

Department of Ceramic Engineering
University of Illinois
Urbana, Illinois

EFFECT OF ALUMINA ON DEVITRIFICATION OF SODIUM OXIDE-DOLOMITE LIME-SILICA GLASSES*

By W. B. Silverman

Abstract

The effect of the substitution of Al_2O_3 for the oxides of sodium, silicon, calcium, and magnesium in the ratio in which they occur in dolomite on the liquidus temperatures and phase relations for glasses lying within the composition range, Na_2O 12 to 16%, $CaO \cdot MgO$ 0 to 20%, SiO_2 63 to 78%, and Al_2O_3 0 to 10%, has been determined. The results on 116 individual determinations are given. Devitrite is the primary phase in very few glasses. Several glasses were found which cannot be devitrified. A comparison of devitrification temperatures of calcite and dolomite-lime glasses is made.

I. Introduction

The existence of large deposits of dolomitic limestone in the Ohio and Pennsylvania district gives this material an economic advantage over calcite limestone. It is therefore not unusual to find that a large percentage of the mass-production glass manufactured in the United States contains lime and magnesia in the proportion found in the mineral dolomite, that is, a 1:1 molecular ratio.

The advantageous properties of glass containing dolomite, when compared with those made with calcite, have become so apparent that dolomite is even used in some areas where calcite has an economic advantage from the standpoint of freight costs. In modern practice, calcite glasses are used only for special purposes or particularly where the freight charges for dolomite become prohibitive. In recent years, however, the addition of alumina to calcite glasses has expanded the use of the latter. The beneficial effects imparted to the glass by small quantities of alumina are well known.

Perhaps the most prominent advantage of dolomite-containing glasses over glasses containing calcite is the lower liquidus temperature that is obtained in a typical production glass where all the calcite lime is replaced by dolomite. This fact is too well known in the industry to need further discussion.

No large-scale investigation has ever been described which completely covers the field of glasses in which the RO of the glass is in the ratio found in dolomite. It is the purpose of this paper to cover that field for glasses of industrial interest containing alumina up to 10%. These data are a part of a larger investigation of the important properties of such glasses.

The system is one of five major components, and the fact that the lime-magnesia ratio is 1:1 does not imply that the crystallization of the various liquids can be followed completely in a tetrahedron representing four components. This method of presenting the data, however, has been used in this paper for the sake of convenience and clarity.

II. Method

The method used for this work has been previously described,[1] and the only refinement has been the use of

* Presented at the Forty-Second Annual Meeting, American Ceramic Society, Toronto, Canada, April 9, 1940 (Glass Division). Received April 9, 1940.

an automatic temperature controller to remove slight temperature variations which were apparent in the furnace owing to line voltage changes. A base metal furnace was used in this particular work, as many of the glasses were devitrified at quite low temperatures.

III. System of Glasses Investigated

The glasses in this series have been made from the following raw materials: Ottawa sand, hydrated burned dolomite, soda ash, aluminum hydroxide, and ammonium sulfate (the amount of the latter was small but sufficient to give approximately 0.2% of SO_3 in the finished glass). The ratio of CaO to MgO in the glasses is slightly higher than in the theoretical dolomite composition owing to the raw materials which were used.

The glasses, in 4- to 5-pound lots, were melted in a covered platinum crucible in a gas-fired furnace. The glass was stirred several times during the melting process with an alloy stirring rod. Several of the more viscous glasses were crushed and remelted to obtain a homogeneous melt. Fragments of the large melt were powdered for the liquidus determination.

All glasses were analyzed; those which varied within more than certain specified limits were discarded, and new melts were prepared and analyzed.

The glasses of this series are divided into several groups containing 0.4, 2.4, 4.4, 6.4, and 8.4% of Al_2O_3. The soda content in each group varied from 12 to 16% in 1% steps. A special series, containing 10.4% of Al_2O_3, 16% of Na_2O, and RO varying from 0 to 10%, was added to supplement the original scheme. The number of glasses at each Na_2O, RO, and Al_2O_3 content is listed in Table I.

TABLE I

Al_2O_3 content (%)	No. of glasses	Na_2O content (%)	No. of glasses	RO content (%)	No. of glasses
0.4	25	12	22	0	1
2.4	25	13	22	2	1
4.4	25	14	22	4	6
6.4	25	15	22	6	11
8.4	10	16	27	8	21
10.4	5			10	21
				12	20
				14	15
				16	10
				18	4
				20	5

The complete analyses as well as the measured liquidus temperatures and phases of the glasses are given in Table II.

IV. Discussion of Results

The individual determinations of liquidus temperatures and primary phases are listed in Table II. The liquidus isotherms of Figs. 1 to 4 are drawn from the original data; those of Figs. 5 to 9 are from a combination of smooth-curve values taken from Figs. 1 to 4 as well as from original data for glasses containing 8.4% and 10.4% of Al_2O_3. The circles in Figs. 1 to 4 indicate the actual composition as determined by chemical analyses. The existence of the devitrite field, in the instances where none of the regular compositions falls in the area that has this compound as the primary phase, was determined by blending two adjacent glasses. Figures 1 to 4 represent parallel planes in the pseudoquaternary system, Na_2O–CaO·MgO–Al_2O_3–SiO_2, at different alumina contents. Each of these planes is parallel to the Na_2O–CaO·MgO–SiO_2 face of the tetrahedron. Figures 5 to 9 represent planes parallel to the CaO·MgO–Al_2O_3–SiO_2 face at different soda contents.

One of the outstanding facts indicated in Figs. 1 to 3 and Fig. 5 is the limited range of composition in which devitrite is the primary phase. This is substantiated by the industrial experience of the rarity of devitrite as the primary devitrification product in dolomite glasses. The compound, however, is often

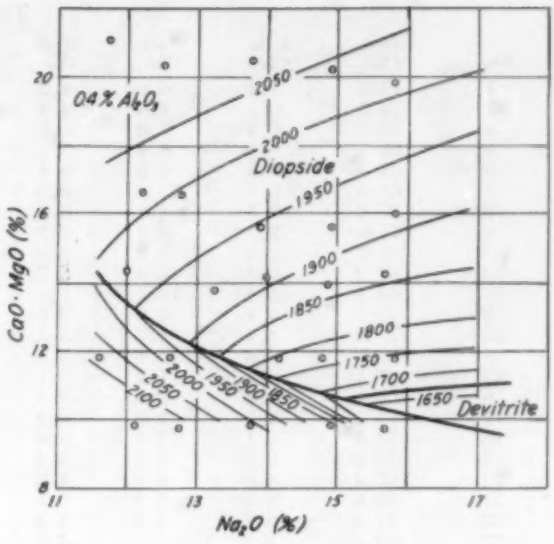

FIG. 1

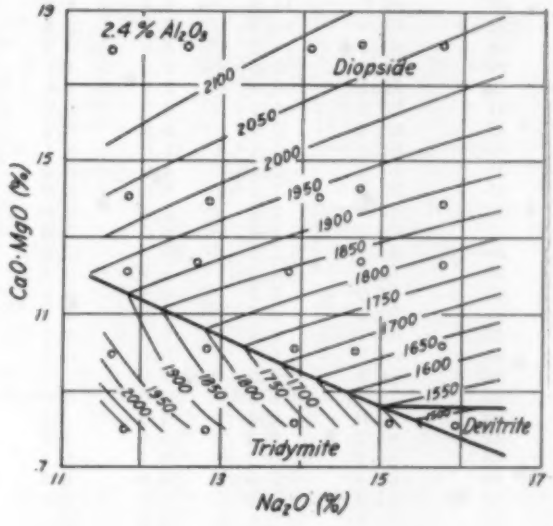

FIG. 2.

[1] W. B. Silverman, "Effect of Alumina on Devitrification of Soda-Lime-Silica Glass," *Jour. Amer. Ceram. Soc.*, 22 [11] 378–84 (1939).

TABLE II*

No.	SiO_2 (%)	R_2O_3 (%)	CaO (%)	MgO (%)	Na_2O (%)	SO_3 (%)	Total	Liquidus temp. (°F.)	Phase
1	71.3	0.2	6.0	4.2	18.0	0.3	100.0	1610	Devitrite
2	73.5	0.3	5.8	4.2	15.6	0.3	99.7	1655	Tridymite
3	71.7	0.3	7.0	4.9	15.7	0.4	100.0	1755	Diopside
4	69.1	0.4	8.4	5.7	15.8	0.4	99.8	1850	"
5	67.4	0.3	9.5	6.5	15.8	0.4	99.9	1910	"
6	63.3	0.5	11.8	8.0	15.7	0.4	99.7	2010	"
7	73.2	2.3	4.8	3.4	15.9	0.4	100.0	1505	Devitrite
8	71.4	2.3	6.0	4.2	15.8	0.4	100.1	1620	Diopside
9	69.3	2.4	7.3	4.9	15.8	0.4	100.1	1770	"
10	67.9	2.3	8.0	5.7	15.8	0.2	99.9	1870	"
11	63.4	2.4	10.7	7.3	15.7	0.4	99.9	2040	"
12	73.2	4.4	3.6	2.6	15.7	0.4	99.9	1500	Tridymite
13	71.9	4.1	4.7	3.3	15.9	0.2	100.1	1650	Diopside
14	69.8	4.3	5.8	4.0	15.6	0.4	99.9	1775	"
15	67.1	4.4	7.1	5.1	15.9	0.4	100.0	1840	"
16	63.6	4.3	9.6	6.5	15.6	0.4	100.0	2020	"
17	73.2	6.3	2.3	1.9	15.8	0.3	99.8		
18	71.3	6.1	3.5	2.6	15.8	0.4	99.7		
19	70.0	6.0	4.6	3.2	15.8	0.2	99.8	1665	Diopside
20	67.4	6.4	6.0	4.2	15.9	0.4	100.3	1840	"
21	63.6	6.4	8.3	5.8	15.6	0.4	100.1	2010	"
22	67.5	8.3	4.8	3.4	16.1	0.1	100.2	1730	"
23	63.1	8.3	7.0	5.0	16.3	0.2	99.9	1970	"
24	73.7	10.4	0.0	0.0	15.9	0.3	100.3	1540	Silica
25	70.9	10.3	1.3	1.1	16.0	0.4	100.0	1660	"
26	69.1	10.5	2.4	1.8	15.9	0.4	100.1	1680	(?)
27	67.8	10.0	3.7	2.6	15.7	0.4	100.2	1655	(?)
28	63.3	10.2	5.8	4.2	16.0	0.4	99.9	1965	Diopside
29	73.9	0.5	6.0	4.1	14.9	0.4	99.8	1860	Tridymite
30	72.1	0.4	7.1	4.9	14.9	0.4	99.8	1790	Diopside
31	70.2	0.4	8.3	5.7	14.9	0.4	99.9	1890	"
32	68.4	0.4	9.5	6.4	14.9	0.4	100.0	1920	"
33	64.1	0.4	12.0	8.1	14.9	0.4	99.9	2050	"
34	73.7	2.4	4.9	3.4	15.1	0.5	100.0	1630	Tridymite
35	72.5	2.4	6.0	4.0	14.7	0.3	99.9	1680	Diopside
36	69.8	2.4	7.4	5.0	15.0	0.3	99.9	1820	"
37	68.2	2.4	8.3	5.8	14.9	0.5	100.1	1930	"
38	64.5	2.4	10.7	7.3	14.8	0.5	100.2	2050	"
39	74.7	4.3	3.7	2.5	14.8	0.3	100.3	1665	Tridymite
40	72.0	4.5	4.8	3.4	15.0	0.4	100.1	1625	Diopside
41	70.2	4.5	6.0	4.2	14.9	0.4	100.2	1780	"
42	68.7	4.4	7.0	4.9	14.9	0.4	100.3	1910	"
43	64.7	4.2	9.5	6.4	14.9	0.2	99.9	2010	"
44	74.9	6.2	2.3	1.8	14.8	0.3	100.3		
45	72.5	6.2	3.6	2.6	15.1	0.1	100.1		
46	70.0	6.4	4.7	3.4	15.1	0.4	100.0	1690	Diopside
47	68.2	6.4	5.9	4.2	15.0	0.4	100.1	1855	"
48	64.1	6.3	8.4	5.8	15.1	0.5	100.2	2055	"
49	68.6	7.9	4.9	3.5	14.8	0.3	100.0	1850	"
50	64.3	8.2	7.2	5.0	14.9	0.2	99.8	1930	"
51	75.1	0.3	5.8	4.1	13.9	0.4	99.6	2000	Tridymite
52	72.8	0.5	7.0	4.9	14.2	0.4	99.8	1785	Diopside
53	71.0	0.4	8.4	5.7	14.0	0.4	99.9	1880	"
54	69.3	0.4	9.4	6.4	13.9	0.4	99.8	1950	"
55	65.4	0.2	12.0	8.3	13.8	0.2	99.9	2070	"
56	75.0	2.3	4.8	3.4	14.0	0.3	99.8	1780	Tridymite
57	72.9	2.4	6.0	4.1	14.0	0.4	99.8	1705	Diopside
58	71.5	2.4	7.2	4.8	13.9	0.4	100.2	1850	"
59	69.1	2.3	8.3	5.6	14.2	0.4	99.9	1960	"
60	65.1	2.5	10.6	7.3	14.1	0.4	100.0	2090	"
61	75.7	4.3	3.5	2.3	14.1	0.3	100.2	1820	Tridymite
62	72.9	4.4	4.8	3.3	14.1	0.4	99.9	1680	Diopside
63	70.8	4.3	6.0	4.1	14.1	0.4	99.7	1860	"
64	68.9	4.4	7.2	4.9	14.1	0.5	100.0	1925	"
65	65.3	4.4	9.6	6.4	14.0	0.5	100.2	2055	"
66	75.1	6.3	2.6	1.8	14.0	0.2	100.0	1725	Tridymite
67	73.0	6.4	3.4	2.6	14.3	0.4	100.1	1550	Diopside
68	71.2	6.4	4.6	3.3	14.2	0.4	100.1	1795	"
69	69.3	6.4	5.8	4.1	14.0	0.4	100.0	1910	"
70	65.5	6.3	8.1	5.8	14.0	0.4	100.1	2060	"
71	69.1	8.4	4.7	3.4	14.1	0.4	100.1	1900	"
72	65.3	8.1	7.1	5.0	14.2	0.4	100.1	2000	"
73	77.0	0.6	5.6	4.0	12.7	0.2	100.1	2150	Tridymite
74	74.7	0.5	6.9	5.0	12.7	0.2	100.0	1950	"

TABLE II (*concluded*)

No.	SiO_2 (%)	R_2O_3 (%)	CaO (%)	MgO (%)	Na_2O (%)	SO_3 (%)	Total	Liquidus temp. (°F.)	Phase
75	72.5	0.5	8.1	5.6	13.2	0.2	100.1	1930	Diopside
76	70.1	0.4	9.7	6.6	12.7	0.3	99.8	1980	"
77	66.7	0.3	11.9	8.2	12.6	0.2	99.9	2090	"
78	76.6	2.4	4.6	3.3	12.8	0.2	99.9	1990	Tridymite
79	75.1	2.1	5.9	4.1	12.8	0.1	100.1	1830	"
80	72.3	2.4	7.3	5.0	12.7	0.3	100.0	1910	Diopside
81	70.9	2.3	8.2	5.5	12.7	0.2	99.8	1970	"
82	66.7	2.5	10.6	7.4	12.5	0.3	100.0	2150	"
83	77.0	4.1	3.8	2.4	12.8	0.1	100.2	1950	Tridymite
84	74.4	4.7	4.7	3.2	13.2	0.2	100.2	1755	"
85	72.6	4.2	6.1	4.2	12.9	0.1	100.1	1880	Diopside
86	70.3	4.5	7.0	5.0	12.8	0.2	99.8	1990	"
87	66.3	4.5	9.4	6.5	12.7	0.3	99.7	2080	"
88	76.6	6.3	2.3	1.6	13.1	0.2	100.1	1825	Tridymite
89	74.4	6.1	3.5	2.6	13.2	0.2	100.0	1735	"
90	72.5	6.3	4.8	3.3	13.1	0.3	100.3	1810	Diopside
91	70.0	6.3	6.0	4.3	13.0	0.2	99.8	1935	"
92	66.6	6.0	8.3	5.9	12.9	0.3	100.0	2070	"
93	71.0	8.1	4.6	3.3	12.9	0.2	100.1	1940	"
94	66.7	8.0	7.0	5.1	12.9	0.3	100.0	2050	"
95	77.6	0.3	5.9	4.0	12.1	0.1	100.0	2160	Tridymite
96	75.9	0.3	7.0	4.9	11.6	0.3	100.0	2080	"
97	73.0	0.4	8.4	6.0	11.9	0.3	100.0	1975	Diopside
98	71.0	0.3	9.8	6.7	12.2	0.1	100.1	2020	"
99	67.3	0.3	12.2	8.4	11.8	0.1	100.1	2090	"
100	77.9	2.3	4.6	3.3	11.8	0.2	100.1	2160	Tridymite
101	75.4	2.5	5.9	4.0	11.6	0.2	99.6	1920	"
102	73.7	2.4	7.0	4.9	11.8	0.2	100.3	1930	Diopside
103	67.5	2.3	10.7	7.1	12.1	0.2	99.9	2140	"
104	77.6	4.3	3.5	2.5	12.0	0.3	100.2	2080	Tridymite
105	75.1	4.3	5.0	3.5	12.1	0.3	100.3	1870	"
106	73.9	4.1	5.9	4.1	11.8	0.1	99.9	1940	Diopside
107	71.7	4.3	7.0	4.9	11.9	0.2	100.0	1995	"
108	67.5	4.6	9.6	6.7	11.6	0.1	100.1	2100	"
109	77.5	6.2	2.4	1.7	12.3	0.1	100.2	1910	Tridymite
110	75.1	6.3	3.5	2.6	12.1	0.3	99.9	1795	"
111	74.1	6.1	4.8	3.2	11.8	0.2	100.2	1835	Diopside
112	72.0	6.2	5.7	4.1	11.6	0.3	99.9	1980	"
113	67.9	6.1	8.3	5.7	11.8	0.2	100.0	2135	"
114	71.2	8.5	4.7	3.1	12.1	0.2	99.8	2000	"
115	67.5	8.4	7.1	5.1	11.9	0.3	100.3	2090	"

* The author wishes to acknowledge the contributions of Paul Close, J. C. Coleman, and C. P. Krepel to this work; Mr. Close and Mr. Krepel for the analytical work and Mr. Coleman for the preparation of the glasses.

found in conjunction with tridymite in devitrified glass taken from pot rims, but in these cases tridymite is the primary phase.

For glasses containing small amounts of alumina, it is noteworthy that the boundary between the diopside and devitrite fields lies at rather low dolomite-lime content, that is, at about 11%. This is considerably lower than the position of the boundary curve between devitrite and wollastonite in calcite glasses where the line extends from about 12 to 15% of CaO.[1]

The first three figures indicate that the quintuple point, diopside-tridymite-devitrite-liquid, occurs roughly at 15% Na_2O content. This is approximately 1% higher than the equivalent point for the CaO system.[1] It is also to be noted that the boundary between tridymite and diopside occurs at from 0.5 to 1% lower RO content than the equivalent boundary in the calcite system. It should be noted that the diopside area is considerably larger than the equivalent wollastonite area and that the devitrite field is very restricted in its extent. These facts adequately explain why diopside is the common primary phase for dolomite-containing glasses.

Figure 4, representing glasses which contain 6.4% of Al_2O_3, shows an area in which the glasses cannot be devitrified by the method herein used within a reasonable time. The circled compositions in the lower right-hand section on this figure were not crystallized. These actual compositions are listed as Nos. 17, 18, 44, and 45 in Table II. As Figs. 1 to 3 all have quintuple points in the immediate Na_2O and $CaO \cdot MgO$ range of the known devitrifying glasses, it may be inferred that these glasses lie close to such a point at the 6.4% Al_2O_3 level. Because the viscosities of these glasses below 1550°F. are extremely high, it is not surprising that an area is reached where crystallization does not occur within a reasonable time. Glass No. 17 was held for eight weeks in the temperature range of expected crystal growth without any indication of devitrification. In a similar manner, glasses Nos. 18, 44, and 45 were held for a period of six weeks.

Figure 5 illustrates the isotherms and phase bounda-

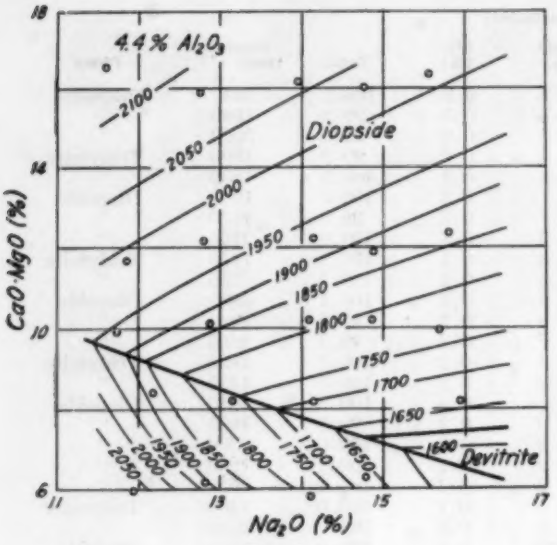

FIG. 3.

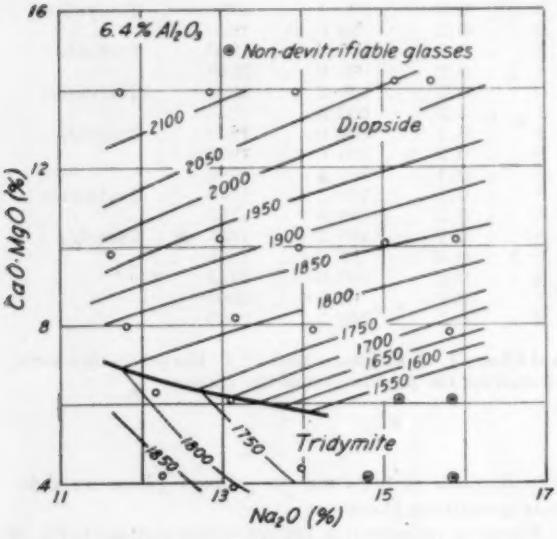

FIG. 4.

ries at 16% Na_2O content. Owing to the difficulties mentioned, no definite location can be given to the quintuple point, tridymite-devitrite-diopside-liquid. A new crystalline phase is also seen to occur in glass containing 10% of Al_2O_3.* There is insufficient information on which to base isotherms in this field, but it is apparent that quite wide spacing of the isotherms is characteristic.

The precipitation of the new crystalline phase is very light in this area. The crystalline properties have yielded no clue as to its composition, but it appears as birefringent rhombs whose indices are of the order of 1.55. The author is of the opinion that these crystals are not quartz because of the liquidus temperatures of

* Reference is made to glasses Nos. 26 and 27, containing 4.2% and 6.3%, respectively, CaO·MgO (Fig. 5).

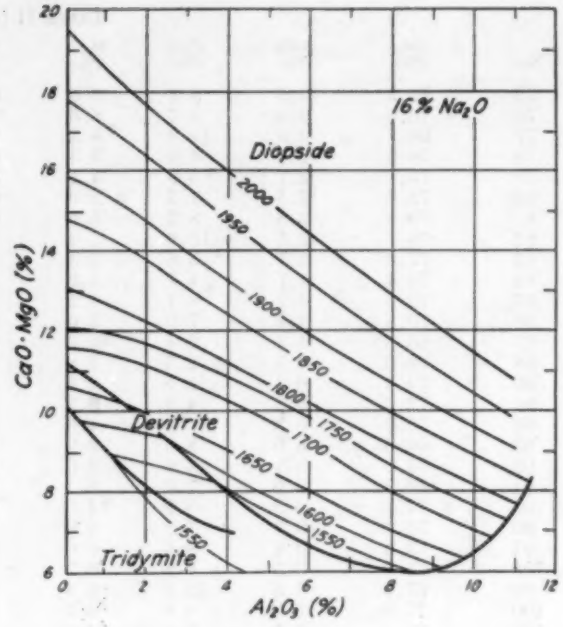

FIG 5.

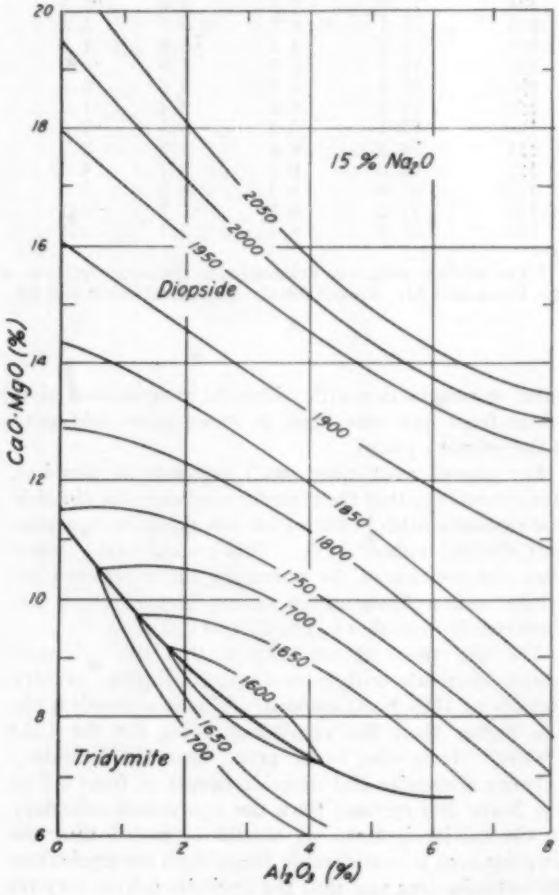

FIG. 6.

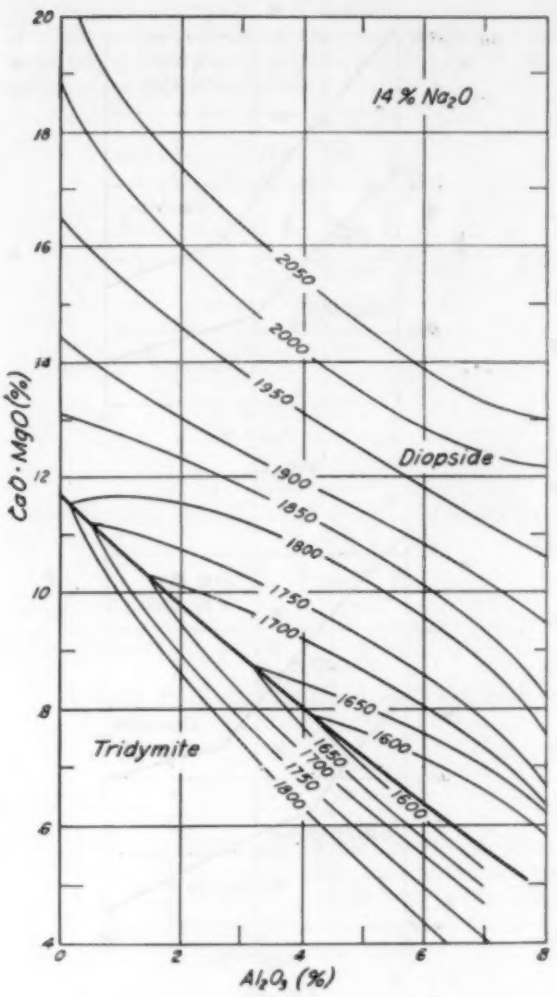

FIG. 7

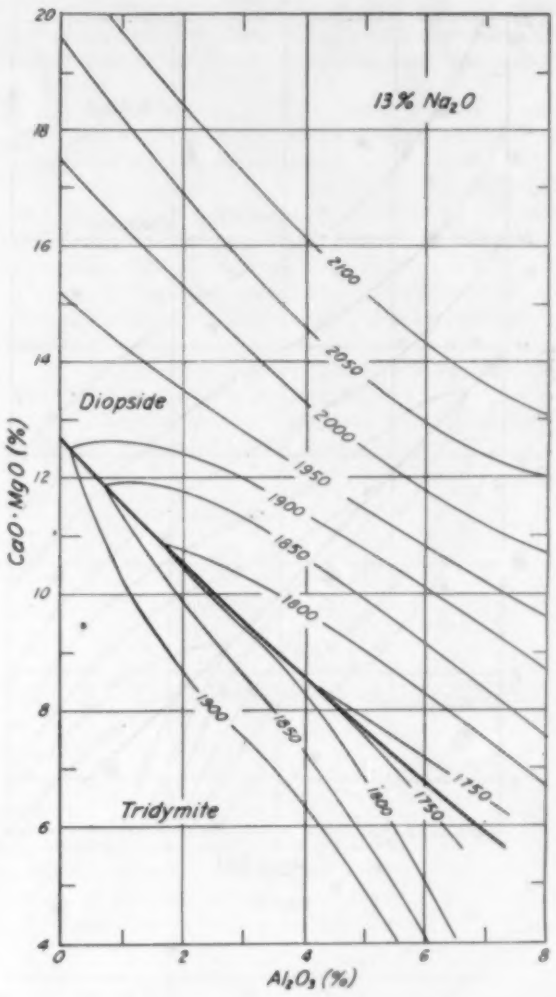

FIG. 8.

the glasses and the fact that previous experience indicates that tridymite or cristobalite continued to be precipitated below the quartz-tridymite inverse temperature.

It is to be expected that this new crystalline phase will form a second quintuple point at the 16% Na_2O level and, from all appearances, this point will not differ greatly in composition from the tridymite-diopside-devitrite point. As in the preceding case, this quintuple point cannot be located definitely from the available data, and no indication of either quintuple point has been shown in Fig. 5 owing to the lack of accurate location of the points.

It may be further reasoned, however, from the proximity of these points, that at a composition not greatly different from those previously mentioned there would be four crystalline phases in equilibrium. These speculations are in line with the appearance of glasses which cannot be easily devitrified at the 6.4% Al_2O_3 level, and this is to be interpreted as the approach to eutectic compositions or, more accurately, a sextuple point.

Within the range of glasses investigated, no phases other than tridymite and diopside were found when the soda content was less than 16%. Only at the 15% Na_2O level (Fig. 6) is there any indication that the diopside-tridymite boundary is so curved as to show minimum RO content similar to that of the 16% Na_2O glasses.

Figure 6 further shows the first closed isotherm in the system at 1600°F., but undoubtedly a few glasses at lower RO which have not been investigated would enable the closing of many others.

The substitution of alumina for silica, when the original glass is in the tridymite area, lowers the liquidus temperature. The effect of the same substitution is reversed and is somewhat more variable for glasses which have diopside as a primary phase.

The substitution of Na_2O for CaO·MgO invariably reduces the liquidus temperature in either field. This is also true for the devitrite area, but the rate is less.

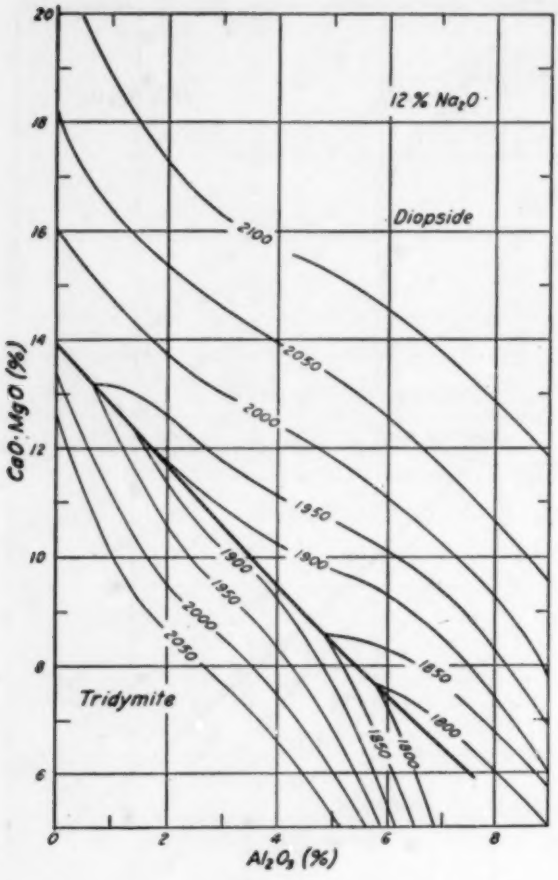

FIG. 9.

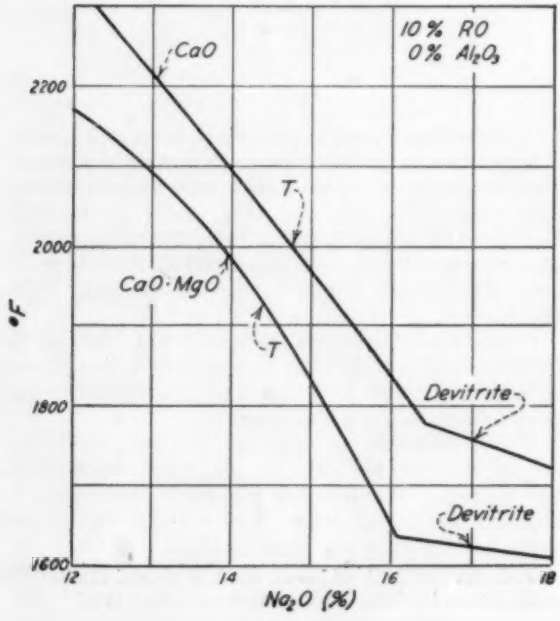

FIG. 10.

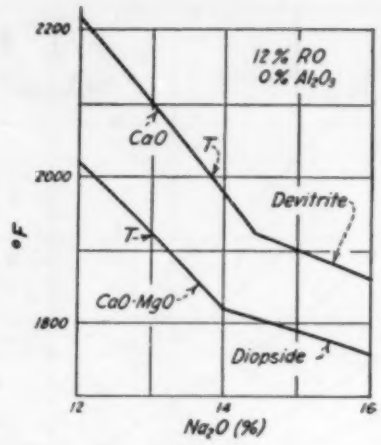

FIG. 11.

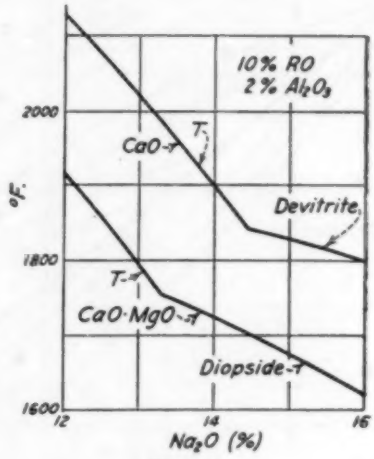

FIG. 12.

In the diopside field, the replacement of dolomite by any of the other constituents decreases the liquidus temperature. In a similar fashion, the removal of silica when the primary phase is tridymite will also lower the liquidus temperature.

V. Comparison of Glasses Containing Equal Amounts of CaO or CaO·MgO

Most container glasses will have RO contents from 8 to 12%, with the Al_2O_3 content being 2.4% or less. Figures 10 to 13 show comparisons for glasses which contain all CaO and all CaO·MgO or a substitution of dolomite for calcite lime. The data for calcite glasses are from a publication of the writer.[1]

It may be seen that the glasses which contained dolomite had considerably lower liquidus temperatures than those which contained calcite. These differences are a function of the composition, but they usually vary from 125° to 200°F. When the glasses contain 12% of RO and 2.4% of Al_2O_3, the difference becomes less, amounting approximately to 80°F. The change of phases has been indicated in the figures.

It should also be noted that an increase from 1 to 3% of silica at the expense of soda may be made when substituting dolomite for calcite and the same liquidus temperature still be maintained.

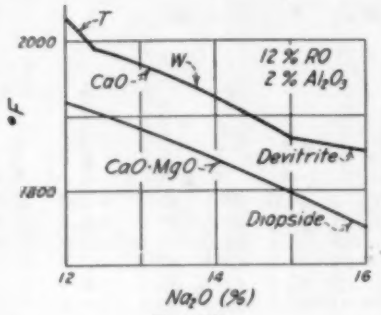

FIG. 13.

VI. Conclusions

The following general conclusions may be drawn from this work:

(1) In the compositional range covered in this paper, dolomite-containing glasses always have lower liquidus temperatures than glasses containing equal percentages of calcite.

(2) When tridymite is the primary phase, a substitution of Na_2O, Al_2O_3, or CaO·MgO for SiO_2 decreases the liquidus temperature.

(3) Any replacement of CaO·MgO by SiO_2, Na_2O, or Al_2O_3 lowers the liquidus temperature of glasses in which diopside is the primary phase. Of these substitutions, Al_2O_3 is the least effective.

(4) The liquidus temperature is lowered in the devitrite field by lowering the CaO·MgO content of the glass.

(5) SiO_2 is more soluble in glasses containing CaO·MgO than in glasses containing CaO.

(6) Devitrite is not a common primary phase in CaO·MgO glasses with soda contents below 16%.

GENERAL RESEARCH LABORATORY
OWENS-ILLINOIS GLASS COMPANY
TOLEDO, OHIO

ANALYSIS OF HIGH-ALUMINA CLAYS BY THE THERMAL METHOD*

BY F. H. NORTON

ABSTRACT

Six samples of clay from Dutch Guiana were analyzed chemically and thermally to determine the silica, the alumina, and the clay minerals present. The thermal method gives excellent quantitative results with a precision of 3 or 4% on clays of this type. Thermal curves are also shown for a few other hydrated iron minerals as data on these were not previously available.

I. Thermal-Analysis Method

The method of thermal analysis has been fully described by the author.[1] In the present work, some refinements have been made by a more accurate determination of standard heat values for pure materials and by more careful weighing of the sample to 0.40 gram which was used for each test. An automatic temperature controller has been developed to bring the temperature up on a given schedule and to put the timing lines on in the proper place so that the test procedure is now entirely automatic.

II. Samples

The clays considered here were six samples received from Dutch Guiana and labeled high-alumina clays. As will be seen later, however, only two of them fall into this category. These clays, however, are sufficiently diverse in character to illustrate well the thermal-analysis method.

III. Results

In Fig. 1 are shown the thermal curves for the six clay samples. Table I gives data both from the chemical analysis and from these curves. It will be seen that the only clay minerals present are kaolinite, diaspore, and gibbsite. The areas under each peak were measured with a planimeter, and this area compared with the standard area for the minerals which have been determined is as follows: pure gibbsite, 1.19 sq. in.; pure kaolinite, 0.64 sq. in.; and pure diaspore, 0.61 sq. in. These values have been corrected for traces of impurities and are all made with a sample of 0.40 gram.

The percentage of each clay mineral is shown in Table I, and from these minerals it is possible to compute the percentage of silica and alumina. In these particular clays, there seems to be little inert matter. The values of silica and alumina are within a small percentage of those determined by chemical analysis; iron minerals occurring in these clays, however, are probably largely hydrated and perhaps are combined

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 9, 1940 (Refractories Division). Received March 22, 1940.

[1] F. H. Norton, "Critical Study of Differential Thermal Method for Identification of the Clay Minerals," *Jour. Amer. Ceram. Soc.*, **22** [2] 54–64 (1939).

TABLE I

	Chemical analysis						Area under thermal peak (sq. in.)			Mineral composition from areas (%)			Oxide compositions from minerals (%)					
Sample No.	Silica	Alumina	Lime	Ferric oxide	Titanium dioxide	Combined water	Kaolinite	Diaspore	Gibbsite	Kaolinite	Diaspore	Gibbsite	Silica	Alumina	R_2O_3 from chemical analysis	Difference	Ratio of $\frac{Al_2O_3}{SiO_2}$ from chemical analysis	Ratio of $\frac{Al_2O_3}{SiO_2}$ from thermal analysis
1	43.9	37.8	1.1	2.7	1.8	14.1	0.62	0	0	97	0	0	45.0	38.3	40.5	+2.2	0.85	0.86
2	44.9	38.8	0.4	2.1	1.3	14.1	0.64	0	0	100	0	0	46.5	39.5	40.9	+1.4	0.85	0.86
3	4.5	58.4	0.4	3.2	2.9	30.6	0.04	0.04	1.05	6	6	88	2.8	64.6	61.6	−3.0	23.0	13.0
4	6.2	60.7	1.3	1.2	1.6	29.1	0.06	0.06	0.85	9	10	77	4.2	62.4	61.9	−0.5	14.8	10.8
5	41.2	37.4	0.3	5.6	1.4	14.4	0.60	0	0.02	94	0	2	43.7	40.0	43.0	+3.0	0.92	0.91
6	44.8	38.2	0.9	1.9	1.5	14.3	0.64	0	0	100	0	0	46.5	39.5	40.1	+0.6	0.85	0.85

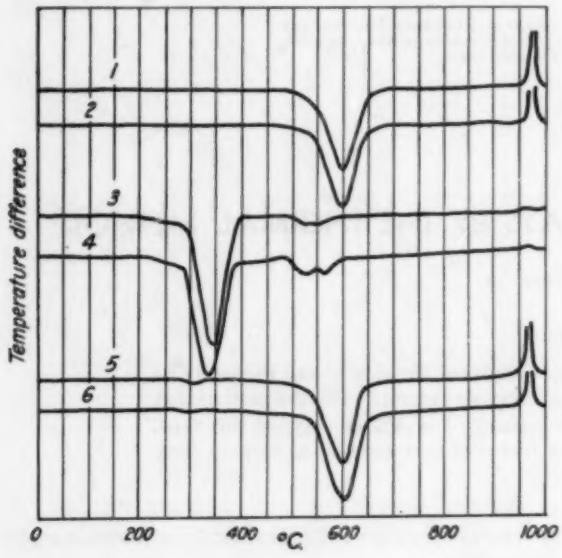

FIG. 1.

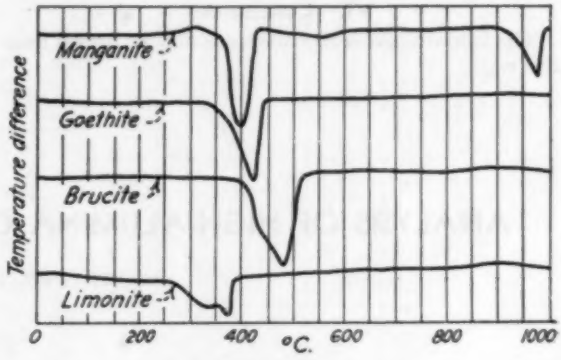

FIG. 2.

with the alumina. If values for R_2O_3, that is, the alumina and iron together in the chemical analysis, are used, there is better agreement with the alumina value found by thermal analysis as shown in Table I. In the last two columns, the ratio of alumina to silica determined by the two methods is given. The agreement is good except for the two high-alumina materials in which the silica is very low.

IV. Significance of Results

It is believed that the thermal-analysis method will be particularly convenient in checking shipments of raw material of fire clays or high-alumina clays, as it will not only give the silica and alumina content quickly and with fair precision but also the accurate amounts of various clay minerals present. For example, there might be two clays having almost identical chemical analysis, and yet one could be high in diaspore and the other high in gibbsite with quite different firing properties. The time required and the cost for running the thermal analysis, furthermore, is much less than for a chemical analysis, as the thermal test can be run in one and one-half hours with little attendance.

V. Thermal Curves of Hydated Iron Oxides

As many of the refractory clays contain some iron oxide, often in a hydrated form, the thermal characteristics of the following pure minerals, on which there are at present but few data, were determined: goethite FeO(OH), manganite MnO(OH), limonite $Fe_4O_3(OH)_6$, and brucite $Mg(OH)_2$. The thermal curves for these minerals are shown in Fig. 2 and indicate very definite peaks where the water is driven off. The position of the absorption peaks and their areas from a standard sample are given below for reference purposes.

Mineral	Peak temp. (°C.)	Area of peak	Remarks
Limonite	275–400	0.30	Double peak
Goethite	325–425	0.44	Narrow peak
Manganite	350–425	0.42	
	900–1000	0.24	
Brucite	400–510	0.94	Broad peak

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

CERAMIC ABSTRACTS

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Ross C. Purdy, Editor

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Journal Reference: The journal name appears in italics, followed by the volume (bold-faced), issue number (in brackets), page numbers, and year (in parentheses).

September, 1940
19—9

Abrasives

Abrasives and their application in foundry practice. H. Bromage. *Foundry Trade Jour.*, **60** [1178] 227–29 (1939).—The manufacture of abrasives commonly used in the grinding-wheel industry is described. The bonding methods used in preparing the wheels are discussed as well as methods of mounting, types of machines, and various foundry applications. A discussion follows. H.E.S.

Data sheet for abrasive wheels: No. 10. Anon. *Can. Machinery*, **50** [10] 41 (1939).—Information on wheels for different materials and operations is given. The kind of abrasive grit, its grade, and the bond are given for different materials and operations in one table. A speed table gives the revolutions per minute for wheels 1 to 60 in. in diameter. Another table shows the recommended peripheral speed (in ft. per min.) and the maximum peripheral wheel speeds for different types of grinding. D.A.B.

Garnets in South Africa. J. Levin. *Minerals Research Lab. S. Africa Bull.*, No. 3, pp. 35–37.—The properties of garnets used in abrasives are discussed. South African and foreign garnets are compared from the standpoints of size, color, appearance, fracture, inclusions, and nonincluded impurities. About 1% of material can be removed by a bar magnet. The results of magnetic treatment are discussed. V.L.B.

Grinding wheels. Norton Co. *Steel*, **105** [16] 73–74 (1939).—Much time and effort has been expended in formulating more efficient intra- and inter-departmental movement of grinding wheels. This product cannot be handled roughly since chipped edges are a cause of rejects. A conveyer system equipped with wood pallets prevents such losses, facilitates production, and lowers costs. Illustrated. H.E.S.

Rigidity and mounting angle control efficient operation of diamond tools. C. J. Koebel. *Can. Machinery*, **50** [6] 118, 120, 122; [7] 21–23, 45–46 (1939).—The application and the care of diamond dressing tools for truing and dressing grinding wheels are described in detail for the practical shopworker. D.A.B.

SEPARATE PUBLICATIONS

Electrometallurgical Investigations: Electrolytic Method for the Production of Calcium Boride. Metallurgical Division Progress Report No. 38. J. Koster, R. G. Knickerbocker, and A. L. Fox. *U. S. Bur. Mines Repts. Investigations*, No. 3500, 20 pp. Free. R.A.H.

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Abrading apparatus. W. L. Keefer (Pangborn Corp.). U. S. 2,205,414, June 25, 1940 (Oct. 13, 1937).

Abrading machine. H. S. Indge (Norton Co.). U. S. 2,206,842, July 2, 1940 (May 13, 1937).

Abrading wheel. E. B. Hubbard (Williams Furniture Co.). U. S. 2,206,355, July 2, 1940 (March 23, 1940).

Abrasive articles. W. J. Tennant (Carborundum Co.). Brit. 522,040, June 19, 1940 (Dec. 3, 1938).

Adhesive abrasive composition. H. O. Richter (Norton Co.). U. S. 2,205,438, June 25, 1940 (Feb. 25, 1936).

Apparatus for dressing or forming grinding wheels used for grinding or finishing gear teeth. Coventry Gauge & Tool Co., Ltd., J. E. Wainwright, and S. J. Harley. Brit. 521,257, May 29, 1940 (Nov. 10, 1938).

Centerless grinding machine. R. H. Cramer (General Motors Corp.). U. S. 2,205,468, June 25, 1940 (Oct. 2, 1939).

Device for sharpening phonograph needles. M. W. Ambrose (Samuel Coty.) U. S. 2,206,932, July 9, 1940 (Oct. 4, 1939).

Drill grinder. F. O. Hoagland (Niles-Bement-Pond Co.). U. S. 2,207,804, July 16, 1940 (Oct. 28, 1938).

Endless abrasive device. Benjamin Grob (Theodore Grob). U. S. 2,208,543, July 16, 1940 (March 2, 1939).

Finish grinding mechanism. Karl Rabe (F. Porsche, K.-G.). U. S. 2,207,268, July 9, 1940 (Nov. 26, 1937).

Grading machine. Nathan Bretholtz (Bretholtz Mfg. Co.). U. S. 2,207,237, July 9, 1940 (March 9, 1934).

Grinding and abrading machines. F. E. Rowland & Co., Ltd., and F. E. Rowland. Brit. 521,370, May 29, 1940 (Nov. 17, 1938).

Grinding cylindrical workpieces. SCHUMAG SCHUMACHER METALLWERKE AKT.-GES. Brit. 522,361, June 26, 1940 (April 26, 1938).

Grinding hard materials. A. NAGY. Brit. 521,697, June 12, 1940 (Nov. 19, 1938).

Grinding machine. W. D. SCHMIDT AND H. L. BLOOD (Heald Machine Co.). U. S. 2,206,732, July 2, 1940 (Nov. 3, 1937).

Lapping machine. M. G. FIEDLER (Fiedler-Sellers Corp.). U. S. 2,208,499, July 16, 1940 (Oct. 10, 1939).

Machine for generating power transmitting surfaces and method. R. P. RENTZELL (Black & Decker Mfg. Co.). U. S. 2,207,177, July 9, 1940 (Dec. 1, 1938).

Machine for grinding gear teeth by the generating process. FRITZ LINSE AND ALBERT BELLMANN. U. S. 2,207,018, July 9, 1940 (Aug. 20, 1937).

Means for sharpening a circular knife. H. L. HASWELL (H. H. Straus). U. S. 2,207,433, July 9, 1940 (March 14, 1938).

Polishing wheel. P. C. MONJAR. U. S. 2,207,439, July 9, 1940 (Oct. 24, 1939).

Producing cloth or paper sheets coated with abrasive particles. CARBORUNDUM CO. Ger. 682,899, Oct. 5, 1939 (May 4, 1935); XII/67*c*. I.—Cloth or paper sheets are coated with abrasive particles by employing a magnetic field to align the abrasive particles on the sheet. The magnetic fields are arranged on both sides of the cloth or paper sheet (opposite poles on each side), and their lines of force cut the sheet almost vertically. D.A.B.

Production of bonded abrasive articles. W. J. TENNANT (Carborundum Co.). Brit. 522,118, June 19, 1940 (Dec. 5, 1938).

Profile-truing device for the grinding wheel of a machine for grinding internal screw threads. SOC. GENEVOISE D'INSTRUMENTS DE PHYSIQUE. Brit. 522,162, June 26, 1940 (Dec. 20, 1937).

Spline shaft grinding machine. RUDOLF WESTENBERGER, WALTER HAUFFE, AND WILLY GEORGI (J. E. Reinecker A.-G.). U. S. 2,206,492, July 2, 1940 (May 2, 1939).

Art and Archeology

Archeological remains near Rusape. T. R. JONES. *Trans. Rhodesian Sci. Assn.*, **37**, 183–85.—Ancient mine workings in granite, fortifications, pottery, and furnaces are described. V.L.B.

Chinese ceramics at the Baltimore Museum of Art. EDWARD S. KING. *Bull. Amer. Ceram. Soc.*, **19** [7] 265–67 (1940).

Features of ductile zirconium and titanium. H. W. GILLETT. *Foote-Prints*, **13** [1] 1–11 (1940).—In a review of the production and characteristics of metallic zirconium and titanium, their possible application in the decoration of glass and glazed ceramic ware is discussed. On glass, the metals leave a silvery streak which can be buffed to a high brilliance, does not tarnish, is not attacked by alkali solutions, and cannot be removed by vigorous scrubbing with soap and hot water. Coatings of good appearance were obtained with 1 gm. titanium for 5500 sq. cm. of surface. A.P.

Handmade pottery in Jutland. A. STEENSBERG. *Antiquity*, **14**, 148–53 (1940).—Hybrid forms of pottery between hand-formed and wheel-made (thrown) pottery have been made in Denmark since primitive times and are still made although they are no longer profitable. This pottery is a direct survival from prehistoric times. The methods of shaping are briefly described; they are of the most primitive kind. The drying is effected in an "earth house" formed by excavation, roofed with porous material, and heated by peat. The firing is done in a flat field without any kiln, the pots being fired under larger ones. The maximum temperature attained is about 500°C. The pottery is shiny (the surface being smoothed with a flint before drying) and black (due to the exclusion of air). Porous pots are made watertight by boiling them in skimmed milk. The shapes and decorations are those of prehistoric pottery. Illustrated. A.B.S.

Pottery from Mount Alice, Essevvale District, Southern Rhodesia. E. T. MEYER. *Trans. Rhodesian Sci. Assn.*, **37**, 187–98.—Various types of pottery are described in detail. The gaps in the existing knowledge of the prehistoric pottery of Southern Rhodesia are stressed. Illustrated. V.L.B.

South African native ceramics; their characteristics and classification. P. W. LAIDLER. *Trans. Roy. Soc. S. Africa*, **26**, 93–173.—A comprehensive classification of South African pottery, from the artistic viewpoint, is presented. Illustrated. V.L.B.

Staffordshire pottery area in the early days of potting. JOHN COX-STEELE. *Pottery & Glass Record*, **21** [11] 273–75 (1939).—Originally, the potteries were built in pleasant, open, hilly country with few roads, and many of the present streets originated as simple paths to the various potteries. Much of the early transport was by water and by horse and cart. Much information on the appearance of the pottery area in early days and its many beauty spots may be obtained from old maps, pottery, and pictures. A.B.S.

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Apparatus for applying decorative color effects to glass and ceramic ware. T. S. BAUMAN (Classic Glass, Inc.). U. S. 2,206,686, July 2, 1940 (Aug. 4, 1937).

Designs for:

Bottle. RAYMOND LOEWY (Parfums Schiaparelli, Inc.). U. S. 121,191, June 25, 1940 (April 22, 1940).

Cup. ISOBEL DARROW (Pacific Clay Products). U. S. 121,156, June 25, 1940 (May 1, 1940).

Footstock for machine tools. M. A. HOLLENGREEN AND R. E. PRICE (Landis Tool Co.). U. S. 121,246, June 25, 1940 (March 29, 1940).

Grinding machine. M. A. HOLLENGREEN AND R. E. PRICE (Landis Tool Co.). U. S. 121,245, June 25, 1940 (March 29, 1940).

Jug. H. G. MCKNIGHT (Owens-Illinois Glass Co.). U. S. 121,192, June 25, 1940 (June 23, 1939).

Plate. VICTOR SKELLERN (Josiah Wedgwood & Sons, Inc., of America). U. S. 121,329 and 121,331, July 2, 1940 (May 14, 1940). VICTOR SKELLERN AND J. E. GOODWIN (Josiah Wedgwood & Sons, Inc., of America). U. S. 121,330, July 2, 1940 (May 14, 1940.) J. T. WIGLEY (Onondaga Pottery Co.). U. S. 121,314, July 2, 1940 (April 1, 1940).

Glaze for ceramic decoration. A. J. DEYRUP (E. I. du Pont de Nemours & Co.). U. S. 2,207,723, July 16, 1940 (Feb. 26, 1936; renewed Oct. 23, 1939).—A glaze for decorating ceramic surfaces having a maturing temperature below about 1100°F. comprises an oxide of lead in amounts ranging from 30 to 45 mole %, silica in amounts ranging from 50 to 65 mole %, an oxide of bismuth in amounts ranging from 0.2 to 10 mole %, and an oxide selected from the group which consists of sodium oxide, potassium oxide, and lithium oxide in amounts ranging from 5 to 20 mole %, all these amounts being by weight based on the weight of the glaze.

Manufacture of luminescent materials. H. C. FROELICH (Harshaw Chemical Co.). U. S. 2,206,280, July 2, 1940 (Jan. 20, 1940).—A luminescent silicate material has incorporated therein from 0.001% to 0.05% of arsenic based upon the weight of SiO_2.

Cements

Calcium aluminate and calcium silicate hydrate. G. E. BESSEY. *Proc. Symposium Chem. Cements, Stockholm, 1938*, pp. 178–215; abstracted in *Chem. Zentr.*, **1939, II**, 3466–67.—After presenting summary tables of the known hydrates, B. treats the system CaO–Al_2O_3–TiO_2 under the following subdivisions: method of preparation (direct synthesis and hydration of the water-free Ca aluminate), optical properties, water content and dehydration, crystal structure, solubility, and phase equilibriums. The system CaO–SiO_2–H_2O is also discussed. See "System . . ." *Ceram. Abs.*, **19** [8] 183 (1940). M.V.C.

Complex calcium aluminate compounds. F. E. JONES. *Proc. Symposium Chem. Cements, Stockholm, 1938*, 231–45; abstracted in *Chem. Zentr.*, **1939, II**, 3466.—A survey of the known complex compounds of Ca aluminate with other salts is given together with information on the method of preparation, properties of the complex Ca aluminates, and their solubility and phase equilibriums. M.V.C.

Mortar products from activated kaolin. RUDOLF BARTA. *Slavivo*, **20**, 326 (1939); abstracted in *Chem. Zentr.*, **1940, I**, 113.—B. calls attention to the fact that a process recently recommended by an American firm for improving mortar materials by adding activated kaolin was registered in a Czech patent (1918) by Barta and Kallauner. M.V.C.

Portland cement and hydrothermal reactions. T. THORVALDSON. *Proc. Symposium Chem. Cements, Stockholm, 1938*, 246–67; abstracted in *Chem. Zentr.*, **1939, II**, 3619.—T. discusses the results of studies on the hydrothermal treatment of Portland cement and its ingredients, dealing with the hydrothermal synthesis of Ca hydroaluminates, hydrothermal alterations of $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ and $2CaO \cdot Fe_2O_3$, hydrothermal treatment of Portland cement and concrete, effect on strength and other physical properties, and resistance to the action of sulfur. M.V.C.

Progressive solubility of silica and R_2O_3 from various pozzuolanic materials and evaluation of their hydraulic activity in relation to the manufacture of normal pozzuolanic products. M. BENELLI AND A. CERESETO. *Atti X° congr. intern. chim.*, **4**, 629–35 (1939); *Chem. Abs.*, **34**, 3463 (1940).—After a general discussion of the different methods used to determine the suitability of various pozzuolanic materials for the manufacture of pozzuolanic cements, the authors advocate the progressive solubility method of Florentin. Solubility determinations were made at the start and after periods of 7 and 28 days; tensile and compression tests were also run concurrently on the 12 materials examined mixed with 15% $Ca(OH)_2$. The data show that the pozzuolanas dissolving to the greatest extent have the greatest mechanical strength; Arno river sand, showing the lowest progressive solubility, has the lowest mechanical strength. In the table of data the complete chemical analyses of the materials tested are also given.

Structure of hydrated Portland cement. B. TAVASCI. *Chimica & Industria*, **21** [12] 656–61 (1939).—A thorough investigation of the structure of hydrated Portland cement, which heretofore has not been thoroughly known, was made by a specially developed method in which no physical or chemical change of the material was involved. While in dehydrated cement four distinct constituents or groups of constituents, *A*, *B*, *C*, and *D*, can be established, another, *E*, exists in the hydrated Portland cement. Constituent *A* is the hydrate of crystalline calcium, $Ca(OH)_2$. *B* represents the basic mass but cannot be considered as the isotropic gel which forms in the hydration of Portland cement. *D* is interpreted as the hydration product of celite in an alkaline medium formed within the cement and as ferrites of calcium formed inside the celite. *C* is a quaternary compound, $2CaO \cdot SiO_2 \cdot Al_2O_3 \cdot aq$. The fifth constituent, *E*, can consist of added $CaCO_3$ or an aluminate which is formed by the addition of $CaCO_3$ to other constituents in the cement. Further studies, particularly of constituent *C*, are advocated. Numerous photomicrographs show the constituents and structures. M.H.

SEPARATE PUBLICATIONS

Building Limes. British Standard Specification No. 890—1940. BRITISH STANDARDS INST., London. Price 3s 6d.—Because of the richly varied character of the different kinds of limestone in the British Isles, bricklayers, masons, and plasterers in one district sometimes fail to work efficiently when using lime from another district. The present specifications do not compare lime from one source with that from another but are intended to show how first-class plaster or mortar can be prepared from limes of various types. *Quicklimes* are of two classes: (*A*) for the finishing coat of plaster, coarse stuff, and building mortar and (*B*) for coarse stuff and building mortar only. The purchaser should state which class he desires and whether a calcium or magnesian lime is desired. Tests required for class *A* are as follows: (1) content of calcium and magnesium oxides; the total calcium and magnesium calculated as oxides shall not be less than 70% of the ignited sample, and the residue shall consist chiefly of silica and alumina soluble in sodium carbonate solution; (2) loss on ignition (not to exceed 5% in lump lime or 7% in ground lime); (3) percentage of carbon dioxide (not to exceed 7%); (4) percentage of insoluble matter (not to exceed 3%); (5) residue on slaking, which may be tested isothermally at any temperature specified by the vendor (not to exceed 5% on a B.S. No. 18 sieve and, after passing through this sieve, not to exceed 2% on a B.S. No. 52 sieve); (6) volume yield of lime putty (not less than 1.7 ml. per gm. of quicklime for calcium lime or 1.4 ml. for magnesian lime); (7) workability (not less than 13 bumps required to cause it to spread 19 cm. on the flow table); and (8) in the case of semihydraulic limes, the hydraulic strength or modulus of rupture (not less than 100 or more than 300 lb. per sq. in. at 28 days). Tests for class *B* are the same as 1 to 5 and, in the case of semihydraulic limes, 8, and the proportions allowed are the same except in test 5, a residue of 5% being allowed for class *B* limes. *Hydrated limes* are also of two classes, *A* and *B*, and the same statements are required of the purchaser. The hydrated lime shall consist of a dry powder. The tests for both classes are the same as those for class *A* quicklimes except that there is no loss on ignition test, the fineness test replaces the volume yield, and a soundness test is added. Eminently hydraulic limes, lime ashes, and natural cements are not included in the specification. See "Hydrated . . ." *Ceram. Abs.*, **19** [6] 140 (1940). A.B.S.

PATENTS

Calcium sulfate, plasters, and cements and products made therefrom. V. LEFEBURE, J. J. ETRIDGE, AND IMPERIAL CHEMICAL INDUSTRIES, LTD. Brit. 521,997, June 19, 1940 (Sept. 28, 1938).

Cement high in magnesia. V. V. SEROV. Russ. 51,995, (Oct. 31, 1937); *Chem. Abs.*, **34**, 3899 (1940).—A clinker containing up to 15% MgO is ground and simultaneously subjected to the action of superheated steam or furnace gases to hydrate the MgO or convert it into carbonate.

Magnesian Portland cement. V. V. SEROV AND I. L. LEFAND. Russ. 52,032, Oct. 31, 1937; *Chem. Abs.*, **34**, 3900 (1940).—Dolomite, limestone, and clay are mixed with roasted pyrite or other material containing Fe_2O_3 and treated in the usual manner for the preparation of cement.

Pigment and method of manufacture. L. W. RYAN AND W. J. CAUWENBERG (Interchemical Corp.). U. S. 2,207,416, July 9, 1940 (April 21, 1937).—The method of preparing gypsum substantially in the form of anhedral particles having an average size of materially less than 5 microns in maximum dimension comprises shattering

gypsum crystals into anhedral particles of the average size by expelling water of crystallization and rehydrating the particles substantially completely while avoiding the presence of a substantial liquid water phase.

Producing hydrated calcium silicate minerals and products thereof. A. W. PARFITT (Gypsum, Lime, & Alabastine, Canada, Ltd.). Brit. 522,271, June 26, 1940 (Dec. 5, 1938).

Enamel

Cast iron for enameling. S. EVANS. *Foundry Trade Jour.*, **61** [1194] 11–12 (1939).—In the manufacture of white porcelain-enameled cast-iron baths, the cast iron requires controlling in regard to silicon, phosphorus, sulfur, and manganese. Scrap of a desirable silicon content and of low oxidation or rusting should be used. The only criterion for coke is its capacity for producing heat. The enamel is an empirical substance, and its control is governed by the varying constitution of the natural products contained therein. Working technique is the cause of practically all trouble. Sand control is essential in obtaining good castings cooled as uniformly as possible in the molds. Pattern control aids in the cleanliness of the process from the rough casting to the enamel shop. Control of the time, temperature, and uniformity of fusion of the enamel is essential. H.E.S.

Control of enamels. A. J. D. BLACK. *Foundry Trade Jour.*, **60** [1185] 371–72, 374 (1939).—The control of enamels in dry-process enameling, including weighing, mixing, milling, fit of enamel to metal, and various testing methods, is described. H.E.S.

Development of opacity in superopaque enamels. BURNHAM W. KING, JR., AND ANDREW I. ANDREWS. *Jour. Amer. Ceram. Soc.*, **23** [8] 228–32 (1940).

Development of a uniform enameling cost system. R. F. HURST. *Enamelist*, **17** [9] 28–29, 54–59 (1940).—In a survey made to compare costs in various enamel plants, it was found that no two plants use the same cost system. Practically all plants operate on a unit of measurement basis, i.e., square foot or pound; others use a fairly accurate cost by operations. The importance and advantages of a uniform cost account system are stressed. A table is presented with the preliminary basic cost units for distribution of labor and material. L.E.T.

Effect of particle size and index of refraction on reflectance. BURNHAM W. KING, JR. *Jour. Amer. Ceram. Soc.*, **23** [8] 221–25 (1940).

Electric furnaces for vitreous enameling. A. G. ROBIETTE. *Foundry Trade Jour.*, **60** [1172] 120–21 (1939).—R. describes the features and construction of electric furnaces for firing ware enameled by the wet process. The advantages of electric heating are as follows: (1) cleanliness, (2) high uniformity and flexibility of heating due to the possibility of grading the heating elements, and (3) the fact that heating may be started by a time switch and control and operation may be automatic. The disadvantages are as follows: (1) thermal economy depends upon continuous and not intermittent operation; (2) capital expenditure is high; and (3) it is not advantageous to vary work and temperature too frequently. **Discussion.** FAULKNER ET AL. *Ibid.*, [1176] 200, 202. H.E.S.

Enameling defects due to the foundry. CHARLES DENNERY. *Foundry Trade Jour.*, **61** [1207] 312 (1939).—Enamel defects caused by the foundry are as follows: (1) formation of blowholes in the enamel due to liberation of gas in the iron, (2) difficulty of enamel adherence to the iron, (3) permanent deformation set up in the iron during enameling, and (4) crazing, due to internal tensions of the enamel during or after enameling. The formation of gas bubbles is the most important, and the source of the gases is traced. H.E.S.

Enameling-shop troubles. A. J. BIDDULPH. *Foundry Trade Jour.*, **61** [1198] 83–84 (1939).—Enamel-shop troubles are usually due to a breakdown in process control. The following specifications for control are recommended: (1) pickling: cleaning, pickling, and neutralizing solutions (with limits of concentration), temperature, impurities, and time cycle; (2) mill room: mill additions with weights of pebbles, time of grinding, fineness, viscosity, temperature, mobility, methods of testing, and use of reclaimed enamel; (3) application: dipping weight per square foot and method of testing, temperature, angle of drain, spraying viscosity, and weight per square foot coverage; (4) fusing: temperature and approximate time for each class of ware, methods of stacking, and notes on handling; (5) inspection: limits of color, passing and not passing; and (6) blasting: sizes and kind of grit and their renewal, air pressure, limits of nozzle size or r.p.m. of impact machine with grit sizes and blade renewal. H.E.S.

Foundry and enamel practice as applied to cast iron. G. M. LOGAN. *Foundry Trade Jour.*, **60** [1185] 368–70; [1189] 447–48, 450 (1939).—The principles involved in the production of porcelain enameled castings are described in detail. The main points of control for wet-process enameling are (1) suitable metal composition and good melting practice, (2) castings with a good smooth skin free from cavities and surface defects, (3) thorough shot-blasting, and (4) correct firing temperature. For dry-process work, the main points are (*a*) suitable metal composition and melting practice, (*b*) castings free from defects, but not to the extent required for wet-process work, (*c*) shot-blasting in all cases, but not so thorough as that required in the wet process, and (*d*) more skillful enamelers. H.E.S.

Glass-lined chemical equipment. A. I. ANDREWS. *Trans. Amer. Inst. Chem. Engrs.*, **35** [4] 473–88 (1939).—The manufacture of glass-lined chemical equipment such as tanks, reaction vessels, pipes, and condensers is described in detail. Illustrated. H.E.S.

Investigation and modern ideas on enamel control. G. H. ABBOTT. *Foundry Trade Jour.*, **60** [1189] 445–47; **61** [1194] 13–14, 18; [1198] 85–86 (1939).—The history and development of enamels is traced from the first work of Bernard Palissy in the 16th century up to the present highly controlled methods. Coefficient of expansion, viscosity of enamel slips, fineness control in grinding, firing procedures, and the use of photomicrographs are discussed and illustrated. **Discussion.** WHITTLE ET AL. *Ibid.*, [1204] 186–87. H.E.S.

Laboratory control of drawing compounds on porcelain enamel metals. D. J. BENOLIEL. *Bull. Amer. Ceram. Soc.*, **19** [7] 259–62 (1940).

Mill-room variations that affect grinding efficiencies. R. L. FELLOWS. *Better Enameling*, **10** [9] 9–12 (1939).—F. discusses factors affecting the grinding efficiency of ball mills used in grinding porcelain enamel. See "Effects . . ." *Ceram. Abs.*, **19** [8] 183 (1940). J.J.H.

Pickle-tank control. WHEELING STEEL CORP. *Steel*, **105** [8] 45–46 (1939).—Potentiometer control substantially reduces maintenance costs, holds solution temperatures within 2 or 3°F. to give better pickling at higher speeds, permits power economies, and lessens damage from accidents. H.E.S.

Porcelain enamel in architecture. J. E. ROSENBERG. *Ceram. Forum*, **6** [6–7] 2 (1939).—The similarity of architectural porcelain enamel and large signs is pointed out. The problems of erection to obtain large perfectly flat sheets, proper suspension of such sheets, and the filling of the joints between individual parts are considered. The fact that progress has been slow is beneficial because time is needed to work out many difficult problems. The chief advantages are appearance and permanency. R. M. KING. *Ibid.*, [10–12] 1, 5.—Porcelain enamel is especially well suited for architectural application because its color and color combinations are unlimited. Being a glass-veneered metal, porcelain enamel parts can be obtained in many

beautiful and elaborate shapes. It can be applied equally well on old or new buildings at a moderate cost. The low maintenance costs due to ease of cleaning, high salvage value, and portability are other important factors influencing its use. H.E.S.

Porcelain metals and architects. M. FINE. *Ceram. Forum*, **6** [6–7] 5 (1939).—Modern architecture has an affinity for porcelain enameled metals because of their unlimited colors, freedom of shape, ease of cleansing, and reasonable cost. Surface treatments of pebble, stipple, terra cotta, mottle, mat, and glass finishes offer interest and freedom to the modern architect. Unlimited fields of endeavor are open to enamel manufacturers. H.E.S.

Problems of the users of vitreous enameled ware. C. A. MASTERMAN. *Foundry Trade Jour.*, **60** [1172] 121–26 (1939).—M. suggests that the ideal method of testing enameled ware would be to have three or four agreed qualities for resistance to acid attack, mechanical damage, and heat and a variety of qualities for resistance to staining. These qualities should be measured by quantitative tests, and the importance of the tests should be determined by the use and application of the particular ware to be tested. A discussion follows. H.E.S.

Production of enameled apparatus. D. I. KENIGSBERG. *Khim. Mashinostroenie*, **1938**, No. 6, pp. 31–32; *Khim. Referat. Zhur.*, **2** [5] 128–29 (1939); *Chem. Abs.*, **34**, 3460 (1940).—The process used in the Leningrad chemical food production plant is described. Steel 1008 is carefully cleaned, coated with a layer of enamel, dried at 80° to 100°, fired, and slowly cooled. This is repeated twice. The upper layer of enamel is then added. The completely fired and slowly cooled parts are then assembled.

Progress in enamel research during 1938. C. R. PLATZMANN. *Chem.-Ztg.*, **63**, 361–64, 384–85 (1939).—The progress in the field of enamel research during 1938 is reviewed from four angles, and 72 references to literature and patents are cited. (1) The subject of raw materials covers the use of borax, tin oxide, zinc oxide, feldspar, and water glass in enamels. (2) The different kinds of enamels include boric acid-free enamels; iron enamels low in carbon, manganese, sulfur, phosphorus, and silicon; lead-free cast-iron enamels; and white turbidified enamels. P. discusses the oxidation and adherence of enamel to iron, acid-resistant enamel production and its problems, the removal of grease from plates before enamel treatment, the use of zirconium, cerium, and tin oxides in fine ceramic products, color oxides from minerals with their production and use, black, white, and colored enamels, the development of the enamel industry, the production of enameled articles, enameled plate, and the future of porcelain-enameled iron. (3) The subject of testing methods includes the detection of surface errors, ridges, hollow spaces, and firing gaps; the chemical determination of metal, oxides of Fe, Co, and Ni in fired enamels; the use of optical devices for testing raw materials and enamels; analysis of glazes, transparency, and color of the finished product; the determination of inner stresses; the effect of harmful dust in the air; and testing instruments and their application. (4) The subject of enamel errors includes heat treatment of plates and cast iron, grinding of enamel charges and the influence of grinding on workability, use of cobalt color, difficulties in enameling cast iron high in sulfur content, running of test samples, influence of carbon and its compounds on enameling, surface stresses and their measurement, and the use of aluminum bronze in enamel work. D.A.B.

Reactions during smelting of superopaque antimony enamel. BURNHAM W. KING, JR., AND ANDREW I. ANDREWS. *Jour. Amer. Ceram. Soc.*, **23** [8] 225–28 (1940).

Reducing enameling costs. J. E. ROSENBERG. *Ceram. Forum*, **6** [6–7] 3–4 (1939).—The following classification of rejected pieces is recommended to find out the cause of rejects: (1) bad rims and brush marks, (2) blackspots, (3) fractured enamel, (4) weld blisters, (5) thin enamel, (6) copperheads, (7) oil spots, (8) point marks, (9) fish scale, (10) water spots, (11) rough enamel, and (12) dirt. Some defects are due to the process, and others are caused by the carelessness of the operator. A careful analysis of the causes offers a means of reducing enameling costs. H.E.S.

Relation of cast-iron composition to pinholes and blistering of porcelain enamels. D. B. NOLAND. *Better Enameling*, **10** [7] 5–7 (1939).—N. discusses the factors that may cause pinholes and blistering of porcelain enamels. The analysis and the composition of the iron have the greatest bearing on the tendency of an iron to pinhole and blister. Conclusions are as follows: (1) a low manganese-sulfur ratio indicates the presence of iron sulfide which usually causes pinholes and blisters; (2) the carbon equivalent is important in ascertaining a tendency toward blistering; (3) the rate and the degree of graphitization definitely govern the firing time and temperatures of the enameling operation; (4) molding and cupola practice, regardless of materials used at the cupola to obtain a satisfactory analysis in the resulting casting, can be such as to produce castings totally unfit for enameling. References are given. J.J.H.

Scientific aids to control in vitreous enameling. G. T. O. MARTIN. *Foundry Trade Jour.*, **60** [1176] 197–200 (1939).—Measurements of the chemical and physical properties of vitreous enamels, such as thickness of enamel, opacity and gloss, chemical resistance, color (by use of the Guild trichromatic colorimeter), and thermal expansion, and mechanical tests such as bending and impact and abrasion resistance are described. A discussion follows. See *Ceram. Abs.*, **18** [11] 292 (1939). H.E.S.

Technical problems in vitreous enameling. J. H. GRAY ET AL. *Foundry Trade Jour.*, **60** [1181] 293–96 (1939).—Enamel consistency and spraying pressure, thermal equilibrium and boiling and blistering of heavy sections, graphitic structure and moisture, design and boiling, use of the nickel dip, and the Hommelaya process are discussed. H.E.S.

Vitreous enamel and its interest to the gas industry. W. J. HARRIS AND J. GREY. *Foundry Trade Jour.*, **60** [1185] 371 (1939).—The wide application of vitreous enamels to appliances and the use of gas as a fuel in this industry have produced a definite interest to the gas industry. The estimated annual consumption of gas in England by the enamel industry alone is 3,600,000,000 cu. ft. H.E.S.

Vitreous enameling. W. H. WHITTLE. *Foundry Trade Jour.*, **60** [1169] 38 (1939).—The Institute of Vitreous Enamelers has made the following contributions to the industry in the past five years (since its incorporation in 1934): (1) It has procured a trade sign for the industry which is eminently adequate to prevent the use or the misuse of the term "vitreous enamel." (2) It has sold more than a half million of the labels evolved from the trade sign. (3) It has issued brochures popularizing vitreous enameled goods. (4) It has organized a series of technical lectures in Scotland, Manchester, Birmingham, and London. (5) It has published four volumes of technical literature. (6) It has organized plant visits to Germany, Belgium, and the U. S. A. (7) It has cooperated with the British Standards Institution for the creation of acceptance specifications. (8) It is financing cooperative fundamental research. It has a membership of over two hundred. H.E.S.

SEPARATE PUBLICATIONS

Sanitary Cast-Iron Enameled Ware. *Nat. Bur. Standards Com. Standards*, CS77–40, 16 pp. Price 5¢.—This standard provides minimum requirements for sanitary cast-iron ware, such as bathtubs, lavatories, kitchen sinks, laundry trays, drinking fountains, etc. See *Ceram. Abs.*, **19** [1] 8 (1940). R.A.H.

PATENT

Applying enamel coatings to iron. WILHELM PÜNGEL AND ROBERT STENKHOFF (Kohle- und Eisenforschung G.m.b.H.). Ger. 688,058, Jan. 25, 1940 (Sept. 6, 1938); VI/48*c*. 1.—The iron is first provided with an outer layer of iron of high purity or electrolytic iron. D.A.B.

Glass

Detection and determination of unusual glass constituents: I, Germanium. W. GEILMANN AND E. STEUER. *Glastech. Ber.*, **18** [4] 89–91 (1940).—In the determination of germanium in glass, decomposition, either by Na_2CO_3 fusion or by HF-H_2SO_4 treatment, is satisfactory. The germanium is isolated by distilling the tetrachloride from a 4 to 5NHCl solution in a stream of Cl_2 or Cl_2 and CO_2. The determination is completed by precipitation and weighing as GeS_2. J.F.H.

Gigantic melting tank for Ford City. ANON. *Amer. Glass Rev.*, **59** [30] 11 (1940).—As part of a $1,700,000 modernization program, the Pittsburgh Plate Glass Co. is building at Ford City, Pa., one of the largest plate glass manufacturing units in existence. The inside dimensions of the tank furnace will be 136 ft. long, 28 ft. wide, and 4 ft. deep. Its capacity will be 1050 tons, with an estimated annual production of 18 million square feet of glass. A.P.

Glass as an electrical insulator. C. J. PHILLIPS. *Jour. Applied Physics*, **11**, 173–81 (1940).—After a brief discussion of the chemical and physical characteristics of various glasses, the electrical properties of glass in bulk and the outstanding characteristics of fiber glass electrical insulation are described. A.P.

"Penoglass." I. I. KITAĬGORODSKIĬ. *Stekolnaya Prom.*, **16** [1] 22 (1940).—Penoglass (multicellular glass) contains numerous closed pores which are separated from each other by very thin glass walls. Such porosity greatly reduces the volume weight of the material and its coefficient of thermal conductivity. The glass insulates against sound and has a high mechanical strength. Finely ground and sifted cullet is the basic material used. The structure of Penoglass depends on (1) the quantity of gas-forming materials (coal, carbonates, sulfates) used, (2) temperature, (3) duration of thermal treatment, and (4) granulometric composition of cullet and gas-forming materials. M.V.C.

Plant study of damaged and defective milk bottles C. T. ROLAND AND H. A. TREBLER. *Jour. Dairy Science*, **21**, 275–81 (1938); *Jour. Soc. Glass Tech.*, **24** [101] 57A (1940).—Most of the impact cracking and breakage was in the lip, neck, and bottom, while thermal shock was chiefly in the lip region. Specimens were taken from (*a*) empty returns, (*b*) bottles in washer, and (*c*) filled bottles in refrigerator and examined for defects, about 1000 specimens from each station being examined. Impact shock occurred largely outside and thermal shock inside the plant. In plants A and B the gill bottles had the highest total rejection percentage, followed by the quarts, half pints, and pints. The latter, however, had a low value for trips per bottle. The figures for plant A were based on a production of 240,000 quart, 68,000 pint, 28,000 half pint, and 10,000 gill bottles, the corresponding figures for plant B being 78,500, 49,000, 37,500, and 5000.

Short methods for chemical analysis of glass. P. A. WEBSTER AND A. K. LYLE. *Jour. Amer. Ceram. Soc.*, **23** [8] 235–41 (1940).

Signal bells of glass. H. JUNGNITZ. *Glastech. Ber.*, **18** [4] 101–102 (1940).—Glass can be satisfactorily substituted for metal in this application. The composition of the glass, form, and wall thickness are important factors in determining pitch. Ordinary soda-lime glass is unsatisfactory. A high lead glass is suitable. J.F.H.

Statistical investigation of relationships in glass technology. HANS FREYTAG. *Glastech. Ber.*, **18** [4] 91–101 (1940).—The use of the Pearson correlation coefficients (C. Boehm, *Chem. Fabrik*, **12**, 433, 445 (1939)) makes it possible to determine whether an expected relation between sets of experimental data exists, the character of the relation, and the form of the relating function. The properties of the correlation coefficient are discussed in detail. The necessary mathematical equations are presented. The method is applied to four practical problems to demonstrate its utility in a great variety of glass problems. J.F.H.

Streaks and the homogeneity of glass. M. FANDERLIK. *Sklářské Rozhledy*, **16** [8] 146–50 (1939); abstracted in *Chem. Zentr.*, **1940, I**, 776–77.—Streaks are classified according to their origin as (1) chemical (when their chemical composition differs from that of the surrounding material) and (2) thermal (when inhomogeneity is due to incorrect thermal treatment). The appearance of streaks, methods of determination and differentiation, and their prevention are described. Photographs of technical glasses and literature references are given. M.V.C.

Thermal shock resistance of milk bottles. C. T. ROLAND AND H. A. TREBLER. *Jour. Dairy Science*, **21**, 575–83 (1938); *Jour. Soc. Glass Tech.*, **24** [101] 58A (1940).—Tests were made using galvanized-iron tanks 36 x 24 x 24 in.; one was heated by a gas flame and stirred, and the other was kept cold by a small stream of cold water. Temperatures were controlled to within 1°F. In the hot tank, bottles stood on wooden slats in the bottom and, after 10 min. or more, were seized individually with wooden tongs, inverted to empty, and plunged bottom down into the cold tank, being completely immersed. When all had been so treated in the order of their immersion in the hot tank, they were removed for examination as soon as possible, since fine cracks tended to close up and become invisible after a short time. Direct sunlight was the best illuminant for inspection. Results of such tests showed that the greatest proportion of cracks occurred in the lip and not near the base, as was found by J. B. Murgatroyd (*Ceram. Abs.*, **17** [4] 140 (1938)) for his method of testing (hot water into cold bottles stood in running cold water). Of two shipments tested of the same make, more than one had 15°F. higher shock resistance than the other, the temperature differences at which 50% cracked being approximately 89°F. and 106°F. The cycle of operations in a triple tank 16 pocket wide Meyer-Dumore washer was studied from the breakage aspect. At the times when greatest cracking was noted the shock "tank 3 to outside brush" was 42° to 45°F. It was also observed that in laboratory tests when hot empty bottles are immersed just to the tip in cold water, a 10°F. lower temperature difference is necessary to cause cracking.

Viscous properties of soda-boric oxide-silica glasses at temperatures from 900° to 1500°F. BURNHAM W. KING, JR., AND ANDREW I. ANDREWS. *Jour. Amer. Ceram. Soc.*, **23** [8] 232–35 (1940).

PATENTS

Apparatus for drawing glass tubes. S. I. KOROLEV. Russ. 55,962, Oct. 31, 1939; *Chem. Abs.*, **34**, 3039 (1940).—Construction details are given.

Apparatus for producing one-piece multifocal ophthalmic lenses. L. L. HOUCHIN (D. D. Hubbell). U. S. 2,208,527, July 16, 1940 (June 14, 1939).

Apparatus for winding glass threads and yarns onto spools. KLAUS SIEGFRIED (A.-G. der Gerresheimer Glashüttenwerke vorm. Ferd. Heye). Ger. 682,937, Oct. 5, 1939 (April 16, 1937); VI/32*a*. 25.—In an apparatus for winding glass threads and yarns onto spools, drums, etc., the spool is interchangeable without a change in speed of the thread or yarn. The spool or drum has cog wheels located at the ends of its axis and rolls off onto obliquely placed racks. D.A.B.

Chilling of glass for tempering. PILKINGTON BROS., LTD., J. B. MITFORD, AND W. W. SHAVER. Brit. 521,854 and 521,855, June 12, 1940 (Nov. 26, 1938).

Electrically heated glass tank furnace. HENRI J. BIVORT. Ger. 679,269, July 6, 1939 (March 19, 1936); VI/32*a*. 4.—An electrically heated glass tank furnace for melting and refining glass masses is described. The reflected heat from the electric heating element arranged above the glass mass serves the purpose of melting, etc. The heating resistances are arranged lengthwise in the furnace, and open outlets are arranged for protecting the resistances against the gas currents moving in the lengthwise direction of the furnace covering. These outlets run

obliquely to the longitudinal axis of the furnace down to the lower section of the furnace. D.A.B.

Fibrous glass felt. GAMES SLAYTER (Owens-Corning Fiberglas Corp.). U. S. 2,206,059, July 2, 1940 (Dec. 24, 1936).

Fusing branch quartz glass tubing onto tubular glass vessels. WILHELM HAGEN (Patent-Treuhand Ges. für elektrische Glühlampen m.b.H.). Ger. 682,828, Oct. 5, 1939 (April 23, 1938); VI/32*a*. 35.—A method is given for the fusing of branch tubing consisting of quartz glass or quartz-like glasses onto tubular glass vessels, e.g., the fusing of evacuating tubular connections of quartz onto the quartz vessel of electrical discharge lamps containing high pressure metal vapors. The quartz vessel is cut through at the point where the branch is to be attached, and a slot extending through the walling is ground into the cut surface of one segment of the tube or into the cut surfaces of both segments in such a manner that both segments of the tube can be put together and then fused. The branch tube (evacuating joint) is then placed onto the channel which results from the fusing together of the tube segments, and these are fused with the walling of the vessel. D.A.B.

Fusing metallic current leads into quartz glass vessels. MARCELLO PIRANI (Patent-Treuhand Ges. für Elektrische Glühlampen m.b.H.). Ger. 688,148, Jan. 25, 1940 (Sept. 24, 1938); VI/32*b*. 10.—Metallic current leads are fused into quartz glass vessels by means of a transitional glass. The transitional glass possesses a melting point above 1550°C. and a coefficient of expansion greater than 0.55×10^{-6} per each degree (centigrade) and is made of at least 75% SiO_2, 1 to 10% BeO, 0 to 10% ThO_2 or commercial grade of cerium oxide (50 CeO + 30 La_2O_3 + 20% oxidic lead mixture), and not more than 5% of other glassforming oxides. D.A.B.

Glass building block manufacture. H. L. EASTUS (Owens-Illinois Glass Co.). U. S. 2,207,342, July 9, 1940 (May 7, 1937).

Hardening glass. EDWIN M. GUYER (Corning Glass Works). Ger. 686,549, Dec. 14, 1939 (Oct. 30, 1936); VI/32*a*. 30.—The glass is heated by the dielectric discharge from a high-frequency field penetrating the glass. The surface of the glass is kept cool during the heating process. D.A.B.

Hardening glass, etc. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Ger. 677,920, June 8, 1939 (Feb. 1, 1936); VI/32*a*. 30.—In a method for hardening glass objects, a gaseous or liquid coolant is blown onto both sides of the heated plastic mass while the article is suspended. The coolant is blown by a spraying nozzle arranged in the walling of a special container, and the withdrawal of the coolant is possible by means of similar special openings arranged in the walling. The cooling process is regulated locally in regard to its force by means of coolant streams running in zones between the receptacle walling and the surface of the article being treated. D.A.B.

Heat-resistant glass. CORNING GLASS WORKS. Ger. 679,155, July 6, 1939 (July 9, 1920); VI/32*b*. 1.—Addition to Ger. 588,643 (*Ceram. Abs.*, **13** [8] 206 (1934)).—Heat-resistant glass contains 76 to 90% SiO_2 and, in addition, alumina, boric acid, and alkali. The boric acid content in the finished glass is not less than 60% or more than 70% of the entire content of alumina, boric acid, and alkali in the glass. D.A.B.

High-melting glasses. EGYESÜLT IZZÓLÁMPA ÉS VILLAMOSSÁGI R. T. Hung. 122,938, Jan. 15, 1940; *Chem. Abs.*, **34**, 3461 (1940).—One or more components of glass (particularly the higher-melting ones) are precipitated from solution as colloidal gels, washed, and evaporated with a solution containing all other components of the glass. The residue is pressed to remove air bubbles and heated to remove all adsorbed water. The temperature is then increased to the melting point, and the mixture is treated in the usual manner.

Hollow building units or blocks. R. HADDAN (Corning Glass Works). Brit. 522,311, June 26, 1940 (Dec. 2, 1938).

Low fusing phosphate glasses. HANS GRIMM AND PAUL HUPPERT (I. G. Farbenindustrie A.-G.). Ger. 688,147, Jan. 25, 1940 (June 17, 1937); VI/32*b*. 1.—A low fusing phosphate glass contains 20 to 30% by weight of alumina (Al_2O_3) in addition to 34 to 44% by weight of phosphoric acid (P_2O_5), less than 12% boric acid (B_2O_3), at least 25% entire alkali, between 8 and 21% sodium (Na_2O), and between 5 and 21% potassium (K_2O). D.A.B.

Making hollow glassware. C. B. GARWOOD (Carr-Lowrey Glass Co.). U. S. 2,205,382, June 25, 1940 (May 19, 1938).

Manufacture of glass wool. GAMES SLAYTER AND J. H. THOMAS (Owens-Corning Fiberglas Corp.). U. S. 2,206,058, July 2, 1940 (Oct. 23, 1936).

Manufacture of vitreous envelopes, e.g., cathode-ray tubes, through which leading-in wires pass. GENERAL ELECTRIC CO., LTD., J. RICHARDS, AND G. W. WARREN. Brit. 522,217, June 26, 1940 (Dec. 8, 1938).

Method and apparatus for fiberizing vitreous material. GAMES SLAYTER (Owens-Corning Fiberglas Corp.). U. S. 2,206,060, July 2, 1940 (March 22, 1938).

Method and apparatus for making glass wool. L. D. SOUBIER (Owens-Corning Fiberglas Corp.). U. S. 2,207,764, July 16, 1940 (April 18, 1934; renewed Dec. 22, 1937).

Microscope objective. HANS BOEGEHOLD (Carl Zeiss). U. S. 2,206,155, July 2, 1940 (Oct. 10, 1938).

Optical glass. L. W. EBERLIN (Eastman Kodak Co.). U. S. 2,206,081, July 2, 1940 (Sept. 1, 1936).—A glass resulting from fusion of a glass batch consists of the oxides of lanthanum, tantalum, thorium, and boron.

Producing a heat-scattering glass. ANTON LUTZ (Siemens-Schuckertwerke A.-G.). Ger. 684,183, Nov. 2, 1939 (July 23, 1937); VI/32*b*. 9.—Quartz crystals still in the crystalline state are imbedded in a glass flux. D.A.B.

Producing openings in the walls of hollow glass objects. CLARENCE E. HAHN AND PAUL P. SHEBEL (International General Electric Co., Inc.). Ger. 679,127, July 6, 1939 (March 13, 1937); VI/32*a*. 27.—Openings in the walls of hollow glass objects are produced by making a spot on the object plastic by heating; an opening is formed by suction from the outside. A hollow die or punch which serves for the transformation of the glass is applied to the plastic spot to be opened and the glass is sucked into the interior of the hollow die or punch. D.A.B.

Production of glass or inorganic fibers. ALGEMEENE KUNSTVEZEL MIJ. N. V. Brit. 521,324, May 29, 1940 (March 10, 1938).

Production of rock-wool products. J. D. MCCARTY AND C. D. RICHARDSON. Brit. 521,525, June 5, 1940 (Dec. 5, 1938).

Sealing glass. KARL STEIMEL (Telefunken Ges. für Drahtlose Telegraphie m.b.H.). U. S. 2,205,582, June 25, 1940 (Dec. 18, 1937).

Sealing vitreous receptacles. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 521,918, June 19, 1940 (Nov. 27, 1937).

Slag wool or rock wool. HEIN & CO. (formerly Haigerer Hütte) (Karl F. Muthmann, inventor). Ger. 685,358, Dec. 16, 1939; 80*b*. 5.07; *Chem. Abs.*, **34**, 4189 (1940).—The molten starting material, such as slag, stone, or earth, is dispersed by means of a suitable pressure medium, such as steam under pressure, within lateral boundary walls without rigid upper or lower enclosures.

Suction apparatus for glass blowing machines. JOHANN MAINZER (Deutscher Verband der Flaschenfabriken G.m.b.H.). Ger. 677,919, June 8, 1939 (March 25, 1937); VI/32*a*. 15. Addition to Ger. 652,661 (*Ceram. Abs.*, **17** [8] 278 (1938).—Suction apparatus for glass blowing machines has two groups of control cams which govern the lifting and lowering motion of the suction form. These cams are located on a shaft deriving its motion from the main drive of the machine. D.A.B.

Surface treatment of glass and other mineral fibers. A. E. EDWARDS (N. V. Mij. tot Beheer en Exploitatie van Octrooien). Brit. 521,982, June 19, 1940 (Nov. 30, 1938).

Telescope eyepiece. ALBERT KÖNIG (Carl Zeiss). U. S. 2,206,195, July 2, 1940 (Dec. 14, 1938).

Tempering of hollow glass articles. PILKINGTON BROS., LTD., AND J. B. MITFORD. Brit. 521,553, June 5, 1940 (Oct. 20, 1938).

Vitreous stems for electric lamps or discharge devices. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 521,917, June 19, 1940 (Nov. 27, 1937).

Wall structures and glass construction blocks therefor. R. HADDAN (Corning Glass Works). Brit. 522,310, June 26, 1940 (Dec. 2, 1938).

Structural Clay Products

Brick manganese in buff firing clays. D. J. CAVANAUGH. *Foote-Prints*, **13** [1] 15–18 (1940).—For uniformity of product, it is essential that manganese applied in the body mix of a buff firing clay be sized carefully, intimately mixed before forming, and fired at a uniform temperature. Slightly reducing atmospheres produce brownish casts, and oxidizing conditions give richer dark gray tones. The amount added is usually not over 1%, and the particular effect obtained depends upon the particle-size proportioning. Absorption is lowered 25% per per cent of manganese at cone 8. A.P.

Clay preparation for vitrified ware. MARTIN LEHMANN. *Tonind. Ztg.*, **64** [5] 30–31; [6] 37–38 (1940).—L. emphasizes the importance of careful clay preparation. The wet process, providing the best and most homogeneous mass, and the combined wet and dry method are discussed in their consecutive phases. F.E.S.

Petrographic study of the bond between brick and mortar. HOWARD R. STALEY. *Trans. Brit. Ceram. Soc.*, **39** [4] 85–100 (1940).—Water penetrates through brick walls between the mortar and brick. High-lime mortars give an intimate, continuous, and permanent bond with the brick. Low-lime mortars give a tentacular type of contact and produce neither continuous nor permanent bond with the brick. Intimacy, continuity, and permanence of interfacial bond are necessary for watertightness of masonry walls. R.A.H.

Physical properties of adobe used as a building material. THOMAS T. EYRE. *Univ. New Mexico Bull., Eng. Ser.*, **1** [3] 32 pp. (1935); *Chem. Abs.*, **34**, 3466 (1940).—Numerous quality tests made on adobe brick in present construction use showed that the lower limit of strength for good adobe was 400 lb. per sq. in. in compression and 70 lb. per sq. in. in tension. A safety factor of 5 or 6 is recommended. The tensile strength values were about 1/8 those found in compression. The mixes with just enough water to obtain proper working had the best strength. Considerable amounts of added straw and manure decreased the strengths. Both Portland cement and lime had deleterious effects on the strength of adobe. Soap and lime additions also weakened the adobe but greatly retarded the absorption of water. Sodium carbonate increased the strength, while Na_2SiO_3, $Al_2(SO_4)_3$, gypsum, iron chips, sand, and swamp-water additions weakened the product.

SEPARATE PUBLICATIONS

Effect of Heating and Cooling on the Permeability of Masonry Walls. CYRUS C. FISHBURN AND PERRY PETERSEN. *Nat. Bur. Standards Bldg. Materials & Structures Rept.*, BMS41. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price 10¢.—Since the coefficients of thermal expansion of masonry units and mortars are unequal, changes in temperature may tend to cause cracks in the mortar joints of masonry walls. Exposure to wind-driven rain may then result in the leakage of water through the walls. Permeability tests were made on 11 small masonry wall specimens before and after exposure to a number of cycles of heating and cooling. Seven of the specimens were 12-in. brick walls, two were of clay tile with stucco facings, and two were brick walls with hollow-unit backings. The walls were dry when subjected to extremes of temperature over a range of about 105°F. The maximum air temperature was about 125°F., and the minimum was less than 20°F. For each cycle, the walls were stored in the heating or cooling rooms until they attained room temperature. Data obtained from the tests indicate that repeated exposures of dry walls to extremes of temperature do not have an important effect on the permeability of all-brick walls. The permeabilities of the walls with facings of brick and backings of hollow units and of those faced with stucco increased slightly as the result of exposure to cycles of heating and cooling. R.A.H.

Glossary of Highway Engineering Terms. British Standard Specification No. 892—1940. BRITISH STANDARDS INST., London. 51 pp. Price 5s.—Technical terms which are to be recognized as standard are defined. Those chiefly connected with ceramics are soil, aggregate, bond, cement, clay, colloid, concrete, crazing, density, elutriation, fineness, gravel, grit, impact test, loam, marl, matrix, mechanical analyses, melting point, mesh, mortar, permeability, plastic limit, plasticity, pug, sand, screen, sedimentation, shale, shingle, sieve analysis, silt, and softening point. Clay is given two definitions: (*a*) colloidally fine complex silicates formed by the natural decomposition of igneous rocks and (*b*) a material composed of particles smaller in size than 0.002 mm. Plasticity is "the property of a material by virtue of which it is permanently deformed when stressed above its yield point." Any conflict with legal meanings or definitions under legal procedure is specially disclaimed. A.B.S.

PATENTS

Hollow brick. JULIUS KLINGELHÖFER. Ger. 679,018, July 6, 1939 (Aug. 3, 1935); V/37*b*. 1.01.—A design is given for brick. D.A.B.

Hollow-wall building construction. W. A. PRIDE. Brit. 522,169, June 26, 1940 (Dec. 2, 1938).

Producing lightweight building material. WOLFGANG CZERNIN. Ger. 679,146, July 6, 1939 (Aug. 16, 1933); VI/80*b*. 18.07.—Oxides or hydroxides of earth alkalis or magnesium and materials high in SiO_2, Al_2O_3, or Fe_2O_3 are mixed, treated with steam, and dried. Fibrous asbestos (8 to 20%) is added to the mass to form a finished product of precalculated specific gravity. D.A.B.

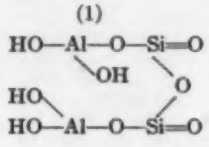
Sweatproof masonry wall. W. C. FULLER. U. S. 2,205,404, June 25, 1940 (March 15, 1939).

Refractories

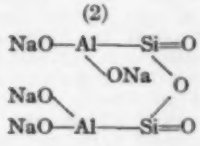
Aiding small furnaces. G. B. GARRETT. *Steel*, **105** [5] 48–51 (1939).—The use of clay spheres in stoves gives a 6% increase in heating surface and 28% more brick mass and permits increasing the blast temperatures from 1100° to 1500°F.; rearrangement of hot blast lines is also beneficial. Illustrated. H.E.S.

Alkaline decomposition of kaolin in the production of alumina. W. D. TREADWELL AND H. SCHNEEBERGER. *Helv. Chim. Acta*, **22**, 1048–58 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 3797.—On the basis of views furnished by Roentgen analyses the following structure formula (1) for kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, was erected and discussed.

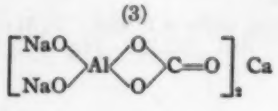
(1)



(2)



(3)



Reaction equations were developed according to which the decomposition of kaolinite with a mixture of Na_2CO_3 and $CaCO_3$ takes place when heated. The decomposition of kaolinite seems to pass over the formation of Na clay (2); the Si atom breaks off through the action of the $CaCO_3$ and orthosilicate is formed with the development of a corresponding quantity of CO_2. To explain the easy formation of soluble aluminate from the action of water on sinter, the formation of an Al-carbonate salt (through the reaction of $CaCO_3$ on the aluminate residue) is assumed in formula 3, whose existence can be supported by the total of the CO_2 developed during the decomposition. The decomposition of kaolinite with Na_2CO_3 and $CaCO_3$ and the dependence of the temperature and time were studied, and it is shown how the quantity of the liberated CO_2 can be calculated. The quantity of the immobilized alkalis and the quantity of silicic acid going into solution during the hydrolytic decomposition were determined. The greater part of the immobilized alkalis can be recovered by hydrothermal decomposition. The remaining insoluble residue has the composition of a Portland cement. M.V.C.

Andalusite from the Marico District, Transvaal. Experiments on its concentration and use as a refractory. V. L. Bosazza and J. Levin. *Minerals Research Lab. S. Africa Bull.*, No. 3, pp. 18–35.—Experimental work in dressing the andalusite sands is described. Flowsheets are given together with the experimental data. Photomicrographs illustrate the character of the andalusite crystals, and chemical analyses show the quality of the concentrates obtainable by the methods finally adopted. As the ore-dressing experiments were conducted on about 30 tons of material, the laboratory work has more than the usual significance. Ceramic tests of briquettes prepared from these concentrates and clay, with the addition of corundum in some cases, show that the material has considerable use in industrial furnaces where conditions are severe on ordinary silicoaluminous refractories. Since the completion of this experimental work, andalusite refractories have been manufactured on a fairly large scale in South Africa. V.L.B.

Basic electric practice for steel castings. C. W Briggs. *Foundry Trade Jour.*, **61** [1209] 269–71; [1210] 289–90, 292 (1939).—The basic electric furnace practice is described, and the following subjects are discussed in detail: (1) furnace linings and materials, (2) charging and melting, (3) double-slag practice (cold scrap), (4) single-slag practice (cold scrap), (5) hot metal charge practice, (6) alumina slag method, (7) manufacture of carbon and alloy steels by the basic process, (8) deoxidation and degasification, and (9) reactions of oxidation and reduction. H.E.S.

Effect of crystalline quartzites and conditions of firing on the increased stability of coke-oven silica brick. I. S. Smelyanskiĭ, V. D. Tsigler, and A. N. Miroshnik. *Ogneupory*, **7** [2–3] 104–14 (1939).—The introduction of Ovruch crystalline quartzites into the mix of handmade products considerably increases the stability of silica brick on firing. The brick are fired at high temperatures (over 1350°) with increased draft in an oxidizing atmosphere. Laboratory tests show that the brick are first grade with respect to chemical, physicochemical, and thermal indices. Refractoriness of the brick is from 1690° to 1710°. See "Effect of composition . . . ," *Ceram. Abs.*, 19 [6] 141 (1940). M.V.C.

Extracting alumina from clays. Felix Singer. *Brick & Clay Record*, **94** [6] 54–58 (1939).—S. discusses U. S., German, British, and Japanese patents covering the methods of extracting aluminum from clays and materials of the bauxite type. He sums up the various processes under the following headings: (1) dry-reducing, (2) acid, (3) sulfurous acid, and (4) Goldschmidt's process. No final conclusion can be given as to which process is the best. None of the processes developed hitherto has proved economical. The economy of the Haglund process depends on whether the ferrosilicon, which is recovered in large quantities as a by-product, can be favorably sold; its value corresponds to about a quarter of the working costs. The future of the Goldschmidt and the Nuvalon processes will depend upon the extent to which losses in acid can be avoided. In industrial countries having a free economy, all the numerous processes for the production of alumina from clay are out of the question for economic reasons. In self-sufficient countries, the old processes of producing alumina from bauxite are still preferred. 20 patent references. J.J.H.

Inorganic binders improve refractories. Anon. *Brick & Clay Record*, **94** [6] 58–60 (1939).—The Lefranc process for the application of inorganic binding agents in industrial ceramic problems is described. It allows the complete elimination of the plastic clay and thereby gives the product new qualities and properties, e.g., greater resistance to chemical corrosion. J.J.H.

Introduction of semiacid refractories in reheating furnaces of the Stalin New Kramatorsk Machine Works. K. I. Popov. *Ogneupory*, **7** [2–3] 141–43 (1939).—The use of semiacid refractories in reheating furnaces instead of grog brick showed their superiority over the latter. The brick were composed of 50% Chasov-Yar clay and 50% quartz sand. M.V.C.

Investigation of the expansion and compression curves of Dinas for use in the construction of the diagrams of the heating and cooling of coke ovens. I. S. Smelyanskiĭ and N. L. Pevsner. *Koks & Khim.*, **7** [4–5] 80–90 (1937); *Chem. Zentr.*, **1938, I**, 4222; *Chem. Abs.*, **34**, 3037 (1940).—Curves for various qualities of Dinas brick (of U.S.S.R.) were determined, and from them the conditions of heating and cooling of coke ovens were derived.

Krivoi Rog pre-Cambrian metamorphous quartzites and vein quartzes as raw materials for silica brick. M. I. Ozhegova, S. V. Potapenko, and I. S. Solonineko. *Ogneupory*, **7** [6] 415–26 (1939).—The chemical, physical, and ceramic properties of the quartzites studied are discussed in detail. M.V.C.

Open-hearth improvements. L. S. Longenecker. *Steel*, **105** [7] 44–46, 74 (1939).—Four open-hearth improvements are illustrated and discussed: (1) a suspended arch, increasing the yield of roof refractories and eliminating the front wall; (2) a new type door with a less exposed water-cooled surface; (3) an auxiliary design of front-wall burners; and (4) a bulk-type charger handling an entire charge in one operation. An estimated saving of $1.023 per ton of ingots is afforded by these improvements. H.E.S.

Preparation of refractory material with a high alumina content. Fernando Babini. *Corriere Ceram.*, **18**, 391–93 (1937); *Chem. Zentr.*, **1938, I**, 4366; *Chem. Abs.*, **34**, 3037 (1940).—Mixtures of clay and Al_2O_3 having the composition $2SiO_2 \cdot 3Al_2O_3$ were divided after the addition of water, and portions were molded by hand while other portions were treated by the Weber filter method. The masses were all fired at 1350° and tested. The material prepared by the Weber method was less porous, possessed a higher resistance to breaking, and showed fewer flaws after firing.

Production of alumina from bauxite mixtures containing sulfates. M. I. Nekrich and A. Yu. Shapiro. *Trudy Kharkov. Khim.-Tekh. Inst.*, No. 2, pp. 106–12 (1939).—It was found possible to obtain Al_2O_3 from bauxite by firing it with sulfates instead of carbonates. Of special interest is the firing of bauxite with gypsum since the latter is practically pure and is an abundant raw material. M.V.C.

Production of highly refractory chrome-dolomite material and concrete and its testing. P. P. Budnikov and M. S. Feĭgin. *Trudy Kharkov. Khim.-Tekh. Inst.*, No. 2, pp. 91–99 (1939).—Results show that unfired chrome-dolomite refractories may replace magnesite and chrome-magnesite brick in steel furnaces. Dolomite raw materials are used for the production of such refractories. See "Highly . . . ," *Ceram. Abs.*, **18** [5] 129 (1939). M.V.C.

Production of pure aluminum compounds from clay. S. Bretsznajder. *Atti X° congr. intern. chim.*, **4**, 8–19 (1939); *Chem. Abs.*, **34**, 3451 (1940).—Possibilities of the production of pure $Al_2(SO_4)_3$ and Al_2O_3 from clay and a known group of clay refining methods based on the decomposition of clay with acids were studied. Those acid

methods which operate in closed cycles suffer from accumulation of impurities (mainly of Fe) in the circulating solutions. In the decomposition of clay by H_2SO_4, when clay is fired at temperatures below 600°, Fe goes into solution more readily than Al; at higher firing temperatures (above 650°) the acid dissolves more Al than Fe. Two methods of removing the Fe compounds from the circulation were examined; one is based on the fact that during the heating of a mixture of $Al_2(SO_4)_3$ and $Fe_2(SO_4)_3$ to 500° to 700°, $Fe_2(SO_4)_3$ is partially converted into Fe_2O_3, while $Al_2(SO_4)_3$ remains unchanged and can be separated from the water-insoluble Fe_2O_3. The other method is founded on hydrolysis of the Fe^{+++} salt at a pH at which hydrolysis of the Al salt is still unimportant. Preliminary purification of Al compounds helps only in the removal of a part of the impurities from the closed cycle of the production. Pure Al compounds can be obtained by crystallization of ammonia alum. Influence of the pH of the solution on the yield of the above crystallization and on the purity of the product was studied. When Fe^{++} is present in the solution, the pH of the solution has no effect on the purity of the crystallized product; when the solution contains Fe^{+++}, a pure product can be obtained by raising the pH of the solution by addition of an alkali but at lower yields. Contrary to the crystallization of ammonia alum, no positive effect of increase of pH on the purity of the product can be noticed during crystallization of $Al_2(SO_4)_3$; at a lower pH the yield of this crystallization is greater. Besides crystallization, there is a possibility of separating pure Al compounds in basic form by hydrolysis of Al salts at an elevated temperature. Basic Al sulfate, free from Fe, can be obtained when all Fe is present as Fe^{++}. Experiments on a semicommercial scale show a possibility of applying these methods to the production of pure Al compounds.

Pyroflex constructions for acid and alkali service. C. A. Rauh. *Trans. Amer. Inst. Chem. Engrs.*, **35** [4] 463–72 (1939).—Pyroflex is a thermoplastic material having a depolymerized colloid resin base. It adheres by fusion to all clean metal, concrete, wood, glass, and ceramic surfaces. It is flexible and nontacky over a wide range of temperature and will not check or crack with severe thermal shock. In dielectric strength, it is approximately equal to hard rubber. Hardness and flexibility can be altered by compounding within certain limits. H.E.S.

Refractories for electric furnaces: I. Everett C. Hite and Gilbert Soler. *Brick & Clay Record*, **94** [6] 48–54 (1939).—The types of electric arc furnaces and the practices of operating these furnaces are discussed in detail. In the basic electric furnace, the refractories are subject to conditions similar to those encountered in the open-hearth furnace. Basic materials must be used for hearths in order to withstand the action of the fluid and corrosive basic slag. Normal bottom construction utilizes fire-clay brick next to the steel shell, then a buffer course of plastic chrome or chrome brick, magnesite brick, and finally a basic grain material which is the working bottom. The buffer course, generally used as a precaution against the possible reaction of the magnesite and fire-clay brick, may be chrome ore, plastic chrome cement, or chrome brick. Fired magnesite brick are generally used in the next zone which is just below the grain material. Unfired brick have not proved entirely satisfactory in this location, particularly where thick coatings of grain materials are used on top of them. Grain materials commonly used are Austrian magnesite, Washington magnesite, dead-burned periclase, chemically precipitated magnesite, dead-burned dolomite, and brucite. These materials are used either in "sintering in" in thin layers or in tamping in a premixed composition. Sintered dolomite can be used successfully in bottom construction for continuous operation, but with intermittent operation it breaks down due to hydration of its lime content by atmospheric moisture. The prime requisite of a furnace hearth is that it must withstand the penetration of molten metal and molten slag. The penetration of the unstable beta dicalcium silicate into the bottom with its subsequent inversion to the stable gamma form on cooling will cause disintegration of the bottom. As electric-furnace hearths are pyroplastic at operating temperatures, little trouble is experienced due to abrasion loss when the furnace is charged. **II.** *Ibid.*, **95** [1] 52–54 (1939).—The normal practice in lining a basic electric furnace is to use acid refractories, viz., silica brick. This practice is not chemically sound but is economically practical. For about 3 ft. around the tap hole, basic brick are used. Neutral refractories (fire-clay or various alumina-silica) have been experimentally tried, but in general these refractories usually give little better service than silica brick. In roof construction of basic electric furnaces, silica brick generally prove most economical. The life of roof refractories is very short, averaging 10 days to 2 weeks. Materials used in constructing the hearth of an acid electric furnace must necessarily be of an acid nature. Normal bottom construction utilizes fire-clay brick next to the steel shell, on top of which are placed silica brick. On top of the silica brick an acid grain material, silica sand, is "sintered in" for the working bottom. Silica brick are used for lining the acid electric furnace. The materials commonly used for lining coreless induction furnaces are ganister or silica sand for acid linings, zircon for neutral linings, and magnesite for basic linings. Chromite and mixtures of magnesia and alumina have also been used. Induction furnaces may be operated with an acid or basic slag depending upon the type of metal being made and the type of lining being used. In many cases no attempt is made in induction furnaces to melt under a slag cover, since, because of the convexity of the bath resulting from the stirring action, it is difficult to keep a slag blanket on the metal. References. Illustrated. J.J.H.

Refractories and molding materials. T. R. Walker. *Foundry Trade Jour.*, **60** [1169] 36 (1939).—Selective grading of raw materials to give proper particle-size distribution of refractory materials is being used as a means of obtaining specific properties in the refractory industry. Colloidal clays similar to but not equal to Wyoming bentonites are being used in England. W. makes a plea for more standardization. H.E.S.

Refractory cements and castables. L. C. Harris. *Modern Power & Eng.*, **34** [4] 22–24 (1940); *Chem. Abs.*, **34**, 4249 (1940).—Desirable characteristics of refractory cement include refractoriness, low shrinkage, similarity in firing behavior to the fire brick used, workability, covering capacity, rigidity retention with load under temperature, and uniformity. Such a cement will protect the fire brick, prevent calcination of the insulation, retard spalling, and decrease furnace outage walls. Bonding cements may be either cold or temperature setting and should be applied in thin layers according to instructions. Shallow patching and heavy patching require different types of material. Proper consistency must be obtained. Heavy patching is successfully done with plastic firebrick material, but this has not been very successful for building up thick walls. A refractory hydraulic setting concrete (or castable) has been developed which can be poured in place like ordinary concrete, and this has been used for a variety of furnace linings, special shapes, oil-burner hearths, etc. These have little drying and firing shrinkage and are spalling resistant. A variety of grades is available.

Refractory jointing cements. F. H. Clews, H. Booth, H. M. Richardson, and A. T. Green. *Trans. Brit. Ceram. Soc.*, **39** [4] 101–19 (1940); condensed from "Jointing cements: IV–VII," *Ceram. Abs.*, **17** [2] 55 (1938). R.A.H.

Refractory products. R. Leduc. *Argile*, No. 197, p. 11 (1939); No. 198, p. 13 (1940).—The life of a refractory does not depend on the amount of alumina which it contains, nor is its resistivity always conditioned by its fusing temperature. Builders demand higher alumina content and fusing point without investigating other factors which might contribute to the premature wearing of the refractories. A refractory brick comprises grains of a refractory material inert to temperature variations and joined by a bonding agent. The plasticity of certain refractory clays permits their use as bonding agent for lean products such as grog or fired clay, discarded broken refractory brick, and refractory sand. The fusing point of a

clay does not characterize it or determine its use, but it should be known so that the exploitation and the manufacture of the refractories may be controlled. The zone of fusibility, which is bounded by the softening point and the fusing point, should be studied because it is useless to require a high fusing point if the refractory has a low softening temperature. Silica brick and its crystalline forms of silica and their transformation are studied. The addition of oxides in the manufacture of silica brick has the following effects: iron oxide facilitates the transformation of quartz into tridymite (Hugill and Reu); wollastonite is formed if the percentage of lime exceeds 4%; when tridymite crystals are added to quartz, they act as catalyzers and aid tridymitization. The addition of a small percentage of oxides transforms the quartz mix into a fused mass, $RO_2 \cdot 5SiO_2$ and $4SiO_2$, when heated. The tridymite crystals form a net which acts as a framework. Most of the oxides aid the transformation into tridymite; alumina facilitates the transformation into cristobalite. This addition of alumina lowers the softening point of the brick and increases porosity. Phosphorite acts as a catalyzer for tridymitization (Budnikov). Boric acid, potash, potassium chloride, chromate of potash, and feldspar containing soda facilitate the transformation of quartz (Wood, Houlsworth, Cobb). See *Ceram. Abs.*, **18** [11] 303 (1939). M.V.C.

Slag control. J. B. Malloy. *Steel*, **105** [26] 46–51 (1939).—Slag-cake characteristics, when thoroughly understood and recognized, permit short cuts in obtaining the desired quality in low-carbon rimming steel for strip. A practical procedure is described for use by the average melter. H.E.S.

Special refractory materials. R. H. Atkinson. Read before the Society of Chemical Industry; abstracted in *Brit. Clayworker*, **49** [577] 40 (1940). R.A.H.

Substitution of refractory brick by fused cement mortars in the construction of pyrite burners for the production of sulfuric acid. A. Tamburini. *Atti X° congr. intern. chim.*, **4**, 70–76 (1939); *Chem. Abs.*, **34**, 3898 (1940).—T. suggests the substitution of the numerous and complicated brick shapes used in pyrite burners by high-Al_2O_3 cement mortars; he points out that great care must be taken to select the proper combination of fine aggregate and high-Al_2O_3 cement and to dry the mortar slowly. Data show that about 32% by weight of high-Al_2O_3 cement gives the highest compressive strength with a fusion point of about 1690° and a softening point of about 1285°, which T. considers safe for pyrite-burner temperatures around 1000°.

SEPARATE PUBLICATIONS

Methods for obtaining the size and warpage of refractory brick and shapes. Stuart M. Phelps. *Amer. Refrac. Inst. Tech. Bull.*, No. 74, 7 pp. (March, 1940).—In measuring refractory brick, tile, or shapes for individual dimensions, all measurements are made by means of a hooked rule. Two sets of measurements for each dimension are made on individual brick, i.e., measurements are obtained on opposite faces and these are averaged for the final dimension. The accuracy required for dimensions up to 9 in. is either $^1/_{64}$ or $^1/_{50}$ in. For dimensions over 9 in., an accuracy of $^1/_{32}$ or $^1/_{20}$ in. is adequate. If the shapes are 3 in. or less in thickness, they are stacked 10 high on a plane and measured to obtain the average stack height. This is done by measuring from the plane surface to the top of the stack at the center of each of the four sides. These figures are averaged before dividing by 10 to obtain the average thickness of the pieces. In measuring warpage, a steel straightedge is placed diagonally across the concave side of the tile. The thin edge of the measuring wedge is slid between the straightedge and the tile at the point of maximum warpage. The amount of warpage is then read from the divisions on the wedge to the nearest 0.02 ($^1/_{50}$ in.). The operation is repeated on the other diagonal, and the larger of the two values of warpage is considered to be that of the tile. These procedures afford a standard method for measuring dimensions and warpage. H.E.S.

PATENTS

Brick formation. G. P. Selby. U. S. 2,206,205, July 2, 1940 (March 13, 1939).—A brick embodies a tapered body section having formed on opposite faces flush with each end thereof alternately arranged lugs and complementary recesses, the lugs on each end of the body section being directly opposite the recesses on the remote end.

Furnace construction. G. L. Danforth, Jr. (Open Hearth Combustion Co.). U. S. 2,206,944, July 9, 1940 (March 9, 1940).

Granular magnesia product. M. F. Goudge (Canadian Refractories, Ltd.). U. S. 2,208,185, July 16, 1940 (May 27, 1939).—Discrete granules of calcined brucite substantially free from lime and other impurities and having a substantially uniform structure of roughly spherical form, the granules being produced by calcination of rock which contains brucite in the form of granules surrounded by a matrix, hydrating the calcined rock, and separating the discrete magnesian granules from pulverulent material.

High melting point silicate refractory. G. E. Seil (E. J. Lavino and Co.). U. S. 2,207,557, July 9, 1940 (Jan. 28, 1937).—A refractory clinker in which the chemical reactions are completed is comprised of interspersed refractory grains of periclase and calcium orthosilicate cemented by monticellite placed in the interstitial spaces between the calcium orthosilicate grains and the periclase grains, with the entire mass uniform and in physical and chemical equilibrium.

Lining brick for rotary cement kilns. G. O. Gross. Russ. 51,938, Oct. 31, 1937; *Chem. Abs.*, **34**, 3900 (1940).—Brick are prepared from cement clinker of large grain (up to 15 mm. in diameter) mixed with 3 to 4% of clay dough and 2 to 3% of an organic or inorganic cementing substance; they are pressed in molds and dried to a H_2O content of 1 to 2%.

Making corrected magnesia refractories. G. E. Seil (E. J. Lavino and Co.). U. S. 2,206,131, July 2, 1940 (Feb. 2, 1937).—The process of making a refractory body comprises mixing grains of crystallized magnesia material and silica flour, wherein the grains of crystallized magnesia will pass through a 6-mesh screen but a majority thereof will be retained on a 100-mesh screen and wherein the silica is of such fineness that substantially all will pass a 100-mesh screen and a major portion thereof will pass a 325-mesh screen, and then firing the mixture to a temperature in excess of 2900°F. to effect a reaction to yield periclase grains having a coating of magnesium orthosilicate formed thereon *in situ*.

Melting magnesium and magnesium base alloys in induction furnaces. Adolf Beck, Herman Schunck, and Günther Ostermann (Magnesium Development Corp.). U. S. 2,208,242, July 16, 1940 (April 13, 1939).—A method of melting magnesium in induction furnaces provided with a lining containing silica consists in first conditioning the lining of the induction furnaces by exposing that portion of the lining which is liable to react with the magnesium to contact with molten aluminum in such a manner as to remove the silica from the portion and thereafter melting magnesium in the thus conditioned furnace.

Preparation of refractory material. G. E. Seil (E. J. Lavino and Co.). U. S. 2,207,072, July 9, 1940 (Aug. 25, 1938).—The process of preparing a refractory clinker comprises grinding the starting materials so that a substantial portion passes a 200-mesh Bureau of Standards screen, tempering the ground material, pressing the tempered material into shapes at pressures of the order of 6000 lb. per sq. in., firing the shapes at temperatures between 3100° and substantially 3500°F. for at least 45 min., whereby the materials are brought into physical and chemical equilibrium and whereby individual brick are bonded together to yield large masses of low porosity substantially free of residual shrinkage, and then crushing these masses.

Refractory mass. E. A. Kogan. Russ. 51,956, Oct. 31, 1937; *Chem. Abs.*, **34**, 3896 (1940).—Magnesite and chromium-iron ore are mixed with water, and sulfite lye is added.

Refractory material for use in basic process siderothermic furnaces. G. B. CRESPI. U. S. 2,206,277, July 2, 1940 (Aug. 18, 1938).—A method of forming a basic lining in a hearth or on other structural parts of a furnace consists in applying finely ground pure calcined dolomite in cold condition in successive layers upon the inner face of the furnace to be treated, stamping the dolomite layers one after the other against the face by a suitable tool until a unified and compact lining is formed, and transforming the lining by action of heat during furnace operation into a petrified monobloc mass.

Refractory nozzles for ladles. MARSHALL & CO. (Loxley), LTD., AND A. MARSHALL, JR. Brit. 521,247, May 29, 1940 (Nov. 9, 1938).

Terra Cotta

Silicate tile. O. KALLAUNER. *Stavivo*, **20** [25] 101–102, 113–14, 277–80, 296–98 (1939); abstracted in *Chem. Zentr.*, **1940, I,** 110–11.—K. gives a survey of the use of ceramic tile (porous, unglazed, glazed, and dense) and vitreous (glass) tile. Attaching tile to the underlying support is very important, especially in the case of outside facing. The effect of sudden severe temperature fluctuations is shown by several experiments. Tile were attached to walls by various means, and after 2 years they were subjected to temperature tests: after heating 1 hr. to 90°, they were cooled with a fan to room temperature; this was repeated and the results were investigated by tapping the tile. Glass tile and borders did not adhere to cement mortar as well as ceramic tile. See "Ceramic . . . ," *Ceram. Abs.*, **18** [9] 247 (1939). M.V.C.

Waterproof resurfacer for cement tile roofs. TRUSCON LABORATORIES. *Steel*, **105** [20] 83 (1939).—A method of treating weather-exposed porous surfaces such as concrete, brick, stucco, tile, etc., is described. The coating consists essentially of two materials: Por-Lox waterproofing, which keeps out water and prevents saponification of the lime found in most concrete and stucco surfaces, and Pro-Lox colored, which is applied over the waterproofing coating and restores coloring to the surface. H.E.S.

SEPARATE PUBLICATIONS

Dimensions for Silica Basins and Capsules. British Standard Specification No. 875—1939. BRITISH STANDARDS INST., London. Price 2s.—Five sizes of basins are specified: 20, 50, 75, 100, and 200 ml. The sizes are given in a table. The capacity of each size equals $0.00016d^3$, where d is the internal diameter in mm. Two shapes of crucible are specified: (1) tall, with the height equal to the external diameter and (2) squat, with the external diameter five-thirds times the height. The five sizes of tall crucibles and four sizes of squat crucibles are shown in a table. The capsules with lids are of two diameters, viz., 75 mm. and 51 mm. The total height is not specified. All these articles are to be made of translucent or transparent silica as stated by the purchaser. A.B.S.

PATENTS

Brick walls, floors, and ceilings. A. G. SHARPLES AND H. A. BRYAN. Brit. 521,170, May 29, 1940 (Nov. 11, 1938).

Ceramic flux. D. A. CANNON. U. S. 2,207,911, July 16, 1940 (April 16, 1938).—A mix adapted for the manufacture of vitrified ware includes fire clay and a ceramic flux, the flux including, in substantially the following proportions, 68.90 silica, 15.78 alumina, 0.28 titania, 2.54 ferric oxide, 0.10 manganese oxide, 2.80 lime, 1.72 magnesia, and 3.28% alkalis.

Flowerpot saucer. I. H. GREENE. U. S. 2,206,694, July 2, 1940 (Dec. 10, 1938).

Whiteware

Dolomite glazes. LADISLAV FEJLEK. *Stavivo*, **20,** 309–10 (1939); abstracted in *Chem. Zentr.*, **1940, I,** 269.—To remove the poisonous $BaCO_3$ as flux in lead-free glazes when firing at low temperatures (1200° to 1300°), F. converted lime and dolomite glazes for porcelain firing at this temperature. Lime glazes were eliminated because of the undesirable greenish tinge. A diagram was made on the basis of 250 dolomite glazes (according to Hegemann-Dettmer), and the limits of the maximum SiO_2 content (in molecules) in dependence on the firing temperature and the quantity of K_2O in dependence on the SiO_2 content are shown. The SiO_2 content has a great effect on the firing temperature. SiO_2 in amount of 2.75 to 3.75 mol. is suitable for the softest glazes (Seger cone 3*a*); 3.75 to 4.25 mol. SiO_2 are suitable for Seger cones 5*a* to 9. The Al_2O_3 content amounts to 0.08 to 0.13 SiO_2. The K_2O content increases with the SiO_2. CaO and MgO increase the fluidity; K_2O reduces it. CaO and MgO help to prevent cracks. A partial substitution by BaO (or ZnO) suffices for mixed glazes or Ba glazes. M.V.C.

Dry mixing in the electrical porcelain industry. R. A. SNYDER AND J. D. HARNISH. *Bull. Amer. Ceram. Soc.*, **19** [7] 258–59 (1940).

Methods of body preparation and their effect on dust pressing of wall tile. RICHARD F. EVANS. *Bull. Amer. Ceram. Soc.*, **19** [7] 255–57 (1940).

PATENTS

Ceramic insulating material. ROSENTHAL-ISOLATOREN G.M.B.H. Ger. 682,959, Oct. 5, 1939 (Sept. 15, 1936); VI/80*b*. 8.21.—A ceramic insulating material for electrical purposes is produced by firing material corresponding to the formula $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ until sintering is brought about and until the named compound is formed. D.A.B.

Leading-in insulators for high-tension electric current. LODGE-COTTRELL, LTD. (Siemens-Lurgi-Cottrell Elektrofilter-Ges. für Forschung und Patentverwertung). Brit. 521,974, June 19, 1940 (Nov. 29, 1938).

Pink pigment for porcelain and similar ware. N. K. ANTONEVICH, N. E. KOLYUN, AND K. V. SALAZKINA. Russ. 51,907, Oct. 31, 1937; *Chem. Abs.*, **34,** 3896 (1940).—Alumina is mixed with $MnCl_2$ and Na_2HPO_4 or $Mn_3(PO_4)_2$, and the mixture is heated at 1200° to 1400° and treated with aqua regia; the pigment is separated, washed, and dried. See "Nature . . . ," *Ceram. Abs.*, **19** [4] 85 (1940).

Porous ceramic articles and their process of manufacture. DOULTON & CO., LTD., AND J. ALLEN. Brit. 521,432, June 5, 1940 (Nov. 19, 1938).

Spark plug. C. E. BERSTLER (R. T. Scull, J. T. Bair, A. W. Golden, and G. S. Weinerth). U. S. 2,208,178, July 16, 1940 (April 15, 1939). E. R. HOLMES (Holmes Induction Devices, Inc.). U. S. 2,208,030, July 16, 1940 (Nov. 6, 1939). J. A. STAHR (C. H. Snyder and C. W. Bosler). U. S. 2,208,059, July 16, 1940 (June 19, 1939).

Spark plug and electrodes therefor. C. H. COLEMAN. U. S. 2,207,311, July 9, 1940 (Feb. 25, 1939).

Water closets, toilet basins, etc. W. C. GROENIGER. Brit. 522,170, June 26, 1940 (Dec. 2, 1938).

Equipment and Apparatus

Apparatus for determining the quantity of air in ceramic masses. S. V. Glebov and A. K. Karklit. *Ogneupory*, **7** [7] 492–04 (1939).—The apparatus is used for the determination of the air remaining in ceramic mixes after dearing. It can be used for plastic or semidry products. M.V.C.

Best production from a ball or pebble mill. O. F. Redd. *Bull. Amer. Ceram. Soc.*, **19** [7] 253–55 (1940).

Centrifugal machine for dewatering moisture samples. George E. Tucker. *Eng. Mining Jour.*, **141** [6] 56–57 (1940).—T. describes the construction and operation of a centrifugal drying device for eliminating excess or free water from samples of iron ore in about two minutes of running time. Illustrated. J.L.G.

Conditioning mill rolls, roll-grinding coolants, approved roll-grinding practice. H. J. Wills. *Steel*, **104** [7] 48–49, 74–75; [11] 48–49; [12] 46–48 (1939).—The production of proper roll surface depends upon careful attention to speed, feed, type of wheel, etc. Coolants best suited for roll grinding are plain water, solutions of soda in water, soluble oils, paste or grease compounds, and soaps. These have varying advantages. The specific defects of roll grinding, such as hammering, scratches, diamond marks, traverse marks, wheel marks, loading, out-of-round, out-of-parallel, and burning, and their causes are examined in detail. Recommendations for various kinds of rolls are discussed, and the best practice for each type is emphasized. H.E.S.

Conveyerized. Kalamazoo Stove and Furnace Co. *Steel*, **105** [3] 50–54, 81 (1939).—High production porcelain enameling tends toward complete mechanization of handling operations. A modernized plant is described as a typical example of mechanized handling in this industry. It features continuous chain-type conveyers. Illustrated. H.E.S.

Determination of water in silicates. C. O. Harvey. *Geol. Survey Gt. Brit. Bull.*, **1**, 8–12 (1939).—The usual methods for determining water in silicates are described, and a modification of the combustion tube method is suggested as being simple yet equally accurate. In making a determination, a weighed amount (2 gm.) of the material is placed in a platinum boat, and the heating is carried out as in the blank test. If the sample evolves CO_2, any of this gas left in the weighing bottle is removed by waving the bottle before stoppering. The method is not applicable to silicates containing much sulfur, but small quantities occasion very little error. A.B.S.

"Dry" furnace practice. L. L. Lewis. *Steel*, **105** [21] 54–58, 82; [22] 42–46, 78 (1939).—Modern air conditioning makes a dry air blast economically practical, and the removal of water vapor from the air blast affords definite economies in coke, increases furnace output, and permits greater uniformity in operation. Outside air conditions and the availability of low-temperature water greatly affect the operation of dry-blast air-conditioning plants. Basic data are submitted for a cost study of the three most practical systems. Illustrated. H.E.S.

Economics of evaporators with forced and with natural circulation. B. V. Florinskiĭ. *Khim. Mashinostroenie*, **1939**, No. 1, pp. 3–11; *Khim. Referat. Zhur.*, **1939**, No. 6, p. 119; *Chem. Abs.*, **34**, 3543 (1940).—Calculations prove that forced circulation is economical only when auxiliary evaporators must be constructed. The practical optimum velocity of the circulation is 1.5 m. per sec. In a number of special cases (highly viscous liquids, an abundance of scum, etc.), it is necessary to use forced circulation regardless of its evaporative usefulness. Increase of the velocity of circulation decreases the heating surface, but the expenditure of energy is thereby increased considerably (in the given example an increase of the velocity from 1.5 to 3 m. per sec. decreased the heating surface by 23% and increased the expenditure of energy by 260%). When determining the expenditure of the energy it is necessary to introduce a correction for boiling (at a velocity of 1.5 m. per sec. the boiling increases the expenditure of power by about 40%).

Fluorescent mercury-vapor lamp as a light source for a single-point check on optical pyrometers. C. F. Lucks and H. W. Russell. *Jour. Optical Soc. Amer.*, **30**, 163–67 (1940).—The 15-watt pink fluorescent mercury-vapor lamp is useful for a quick, convenient, single-point check on an optical pyrometer. A.P.

Improved apparatus for the separation of heavy minerals. W. Hugill. *Trans. Brit. Ceram. Soc.*, **39** [4] 120 (1940).—This apparatus is useful for separating small quantities of crystals or ferruginous material from large amounts of crushed brick. R.A.H.

Improved method of calculation of drying time. J. C. Brier and A. S. Foust. *Trans. Amer. Inst. Chem. Engrs.*, **35** [6] 797–800 (1939).—A simplified calculation of the time required for drying solids under constant conditions is presented, and it is shown that a logarithmic mean drying rate can be applied to the falling rate period of drying if the drying rate curve is a straight line. Application of the method to that portion of the drying cycle in which the rate curve is not a straight line is discussed. H.E.S.

Interpretation of sizing analyses. A. O. Gates. *Eng. Mining Jour.*, **141** [6] 51–54 (1940).—G. shows how the law of size distribution simplifies the mathematics of crushing and sizing. 4 figures. J.L.G.

Methods for investigation of the fine fractions in clays and cements. O. E. Radczewski. *Z. Ver. Deut. Ing., Beiheft Folge*, **1939**, No. 6, pp. 172–80; *Chem. Abs.*, **34**, 3458 (1940).—New methods include the use of sedimentation, the centrifuge, turbidimetry, X-ray analysis, and microscopic analysis for the determination of both grain size and size distribution. Diagrams, photomicrographs, and 32 references are given.

Mixing of solids. Mixing of binary system of two sizes by ball-mill motion. Yositosi Oyama. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **37**, 17–29 (1940) (in English); *Chem. Abs.*, **34**, 3139 (1940).—The completeness of mixing, as judged by the specific volume of the mixture after milling, increases with speed of rotation to a maximum at about 60 r.p.m.; at higher speeds, the character of the motion of the particles changes and mixing is less efficient. Photographs are given showing formation in the bed of transverse strips of the different size particles under conditions of less efficient mixing. Ball-mill mixing is not so efficient as the horizontal oscillation method studied by Westman (*Jour. Amer. Ceram. Soc.*, **19** [5] 127–29 (1936)).

Mouthpiece and "dog's teeth." Anon. *Tonind.-Ztg.*, **64** [3] 18–19 (1940).—The reduced output of the auger machine through raggedness is mostly caused by improperly designed dies. Suggestions and drawings for correctly designed mouthpieces are given. F.E.S.

New viscometer. L. Christophe-Tschakaloff. *Rev. pétrolifère*, No. 875, pp. 111–12 (1940); *Chem. Abs.*, **34**, 3541 (1940).—In a viscometer of the rotary-cylinder type, the vertical cylindrical body is caused to rotate between two other coaxial cylinders enclosing a portion of the liquid within a container. The weights actuating the cylinder are selected so that the time for one revolution is a simple fraction (0.001, 0.01, or 0.1) of the absolute viscosity. The apparatus has been constructed in two sizes: one covers the viscosity range of 0.015 to 250 poises and is intended for lubricating oils, while the other (0.4 to 100,000 poises) is suitable for asphalts, etc. Since the cylinder is supported on balls, errors due to misalignment are negligible.

Optical properties of quartz at wave lengths of 8 to 20μ. W. Stein. *Ann. Physik*, **36** [5] 462–84 (1939).—S. measured the transmission and reflection of crystalline and amorphous quartz with plates 12.8, 20.7, 36.2, 83.0, and 157.8μ thick at wave lengths ranging from 8 to 20μ. The transparency of crystalline quartz showed strong dichroism and a high maximum at 16.5μ; this maximum does not exist in quartz glass. The reflection spectra are very similar in crystalline and amorphous quartz. Amorphous quartz is therefore preferable to quartz glass as a filter material, especially in the range near 16.5μ. M.H.

Overstrom mud screen. G. W. JARMAN, JR. *Bull. Amer. Ceram. Soc.*, **19** [7] 251–53 (1940).

Potentiometer circuit for portable optical pyrometer. R. C. MACHLER. *Rev. Sci. Instruments*, **10** [12] 386–88 (1939).—M. describes a potentiometric circuit designed for the measurement of small currents, together with its application to the measurement of the filament current in a portable optical pyrometer. Several elements are eliminated from the conventional potentiometer, giving the advantages of increased portability and simplicity of operation. H.E.S.

Problems around the auger. K. A. KIESS. *Tonind.-Ztg.*, **64** [6] 35–36; [7] 43–44; [8] 49 (1940).—K. discusses the circumstances which led Schlickeysen to his invention of the auger machine and describes the shortcomings of the machine in the early stages. The structure problem and the deairing question are dealt with. Various suggestions for improvement of the auger machine are offered. F.E.S.

Properties of mixtures of air and saturated water vapor for barometric pressures from 22 in. to 32 in. of mercury. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **12** [5] 311–12; [6] 373–74 (1940).—Values are tabulated for 30 and 31 in. of mercury from −40° to +200°F. See *Ceram. Abs.*, **19** [5] 121 (1940). J.L.G.

Psychrometric chart, application and theory: XII. WILLIAM GOODMAN. *Heating, Piping & Air Conditioning*, **12** [5] 303–305 (1940).—G. presents four appendices which indicate how the equations of previous articles were derived. 1 table, 1 chart, 1 figure. **XIII.** *Ibid.*, [6] 367–69.—Appendices five, six, and seven contain derivations of equations that appeared in previous articles. For Parts **X** and **XI** see *Ceram. Abs.*, **19** [7] 169 (1940). J.L.G.

Radiation pyrometer. JOHN STRONG. *Jour. Optical Soc. Amer.*, **29**, 520–30 (1939).—S. describes a radiation pyrometer intended primarily for measuring temperatures ranging from −100°C. to +100°C. with an accuracy of 0.1°C. The pyrometer uses a band of wave lengths at 8.8 microns in the infrared region. Many applications of the instrument are concerned with surfaces which radiate as black bodies. A.P.

Spray rinsing. J. D. TIERNEY. *Steel*, **105** [23] 63–69 (1939).—The use of high-velocity spray rinsing permits important savings of floor space and water consumption, decreases the work and time involved, eliminates carry-over between solutions, and improves the quality of work by more effective rinsing. H.E.S.

SEPARATE PUBLICATIONS

Polarizing Comparison Microscope for Petrographic Measurements. GEORGE T. FAUST. *U. S. Bur. Mines Repts. Investigations*, No. 3503, 7 pp. Free.—F. discusses the application of the polarizing comparison microscope to problems directly concerned with mineral dressing where it is desirable to compare analogous products and suggests new uses in various related fields. R.A.H.

PATENTS

Apparatus for cutting off clay tubes by employing a wire cutter. JOSEF HECKENBERGER. Ger. 677,950, June 8, 1939 (Nov. 11, 1937); VI/80a. 42. Addition to Ger. 669,532 (*Ceram. Abs.*, **18** [6] 162 (1939)).—To cause motion of the frame, the bottom roller is placed on a common frame on one end of which is fixed a double lever and on the other another lever which lifts or lowers the bolt supporting the frame by the turning of a thumb nut on a thread screw. D.A.B.

Apparatus for extracting grit and dust from air and gases. A. PARKER AND J. A. PARKER. Brit. 521,847, June 12, 1940 (Nov. 26, 1938).

Brick press. G. W. REED. U. S. 2,208,054, July 16, 1940 (June 21, 1937).

Dispensing device. C. W. VOGT (Owens-Illinois Glass Co.). U. S. 2,206,986, July 9, 1940 (June 3, 1937).

Dispensing receptacle. C. W. VOGT (Owens-Illinois Glass Co.). U. S. 2,206,984, July 9, 1940 (Nov. 6, 1936). U. S. 2,206,985, July 9, 1940 (Dec. 2, 1936).—A device for discharging the contents of a flexibly walled container.

Driving mechanisms for potters, jiggers, etc. W. BOULTON, LTD., AND C. FARR. Brit. 521,631, June 5, 1940 (Nov. 24, 1938).

Drying ceramic articles by action of high-frequency electric field. SIEMENS-SCHUCKERTWERKE A.-G. Ger. 684,276, Nov. 25, 1939; 82*a*. 1.01; *Chem. Abs.*, **34**, 3462 (1940).—An electric current which is appreciably greater than that which corresponds to the amount of moisture of the article is employed at the beginning of the drying process. After attaining the moisture limit, at which an increase of the temperature of the article above the boiling point of the liquid to be separated occurs, the current is reduced and is automatically regulated.

Glassy shapes and method of producing. MAURIZIO KORACH AND A. DAL BORGO. U. S. 2,208,034, July 16, 1940 (May 29, 1936).—The method of producing thin plates from materials forming, when fused and solidified from the fused state, glass-, glaze-, or enamel-like masses comprises depositing on a molding support capable of withstanding the melting and firing temperature a batch of fusible material of the kind above described, the constitution of the batch to be deposited on the support being so chosen that the layer solidified from the fused state can readily be detached from the support, heating the support together with the batch deposited thereon to effect fusion of the batch, and detaching from the support the layer formed by fusing.

Gravity separation of ores. H. H. WADE (Minerals Beneficiation, Inc.). U. S. 2,206,980, July 9, 1940 (March 31, 1938).

Grinding mill. HARLOWE HARDINGE (Hardinge Co., Inc.). U. S. 2,206,477, July 2, 1940 (July 30, 1937).

Machine for subjecting materials to tensile, compression, bending, and hardness tests. J. W. H. ARNTZEN. Brit. 522,219, June 26, 1940 (Dec. 9, 1937).

Material-handling apparatus. D. W. KENT AND FRED VAN DOORNINCK (C. K. Williams & Co.). U. S. 2,207,987, July 16, 1940 (Aug. 6, 1935; renewed Dec. 1, 1938).—A calcining furnace includes a muffle, the muffle having a plurality of concentric drums forming a muffle chamber therebetween and having means to raise material within the muffle chamber alternately and to spread the material over parts of both drums alternately during rotation, the raising means including a plurality of flights projecting into the muffle from both drums and engaging the material to be treated, each flight being secured to one drum and spaced from the other drum, means to rotate the muffle, and means to heat the drums from without the muffle chamber.

Means for distributing comminuted material flowing in a duct in desired proportions. W. W. GROVES (Combustion Engineering Co., Inc.). Brit. 521,959, June 19, 1940 (Nov. 29, 1938).

Recording potentiometer. C. O. FAIRCHILD (Charles J. Tagliabue Mfg. Co.). U. S. 2,207,343, July 9, 1940 (Dec. 31, 1935). U. S. 2,207,344, July 9, 1940 (Dec. 31, 1935; May 11, 1939).

Silk screen printing machine. E. E. PERRY AND F. A. CAMERON (E. E. Perry). U. S. 2,207,818, July 16, 1940 (June 9, 1939).

Spraying device. RUDOLPH BERNHARDT. U. S. 2,208,067, July 16, 1940 (Feb. 20, 1939).

Tile-cutting machine. N. C. COATES. Brit. 522,194, June 26, 1940 (July 25, 1939).

Tile scoring and breaking device. F. A. FEDON. U. S. 2,205,717, June 25, 1940 (Sept. 11, 1939).

Vibratory screen. E. J. WINKLEMAN (Duquesne Slag Products Co.). U. S. 2,207,844, July 16, 1940 (Aug. 10, 1937).

Kilns, Furnaces, Fuels, and Combustion

Automatic stokers save 40% in fuel on rectangular brick kilns. ANON. *Brick & Clay Record*, **94** [6] 15–16 (1939).—The use of automatic type stokers in the shale face brick plant of the Plainville, Ga., Brick Co. is discussed. The stokers are mobile, the hopper, transmission, motor, and fan being joined up to the air and feed tube as needed. Only the furnace castings are permanently installed. Advantages include (1) a 40% saving in fuel costs, (2) savings in time, both in the watersmoking period and in firing, (3) more uniform color and size in the brick and thus a reduction in "seconds," (4) use of lower priced coal, (5) some saving in firing labor, and (6) increased production. Illustrated. J.J.H.

Circulation of combustion gases in heating installations, in particular in gas-fired industrial furnaces. A. R. LEYE. *Gas- & Wasserfach*, **83** [14] 157–61; [15] 173–76 (1940).—An investigation was made to determine to what extent the circulation of the combustion gases can increase the economy and efficiency of a heating installation. The returning waste gases can be utilized by mixing them with (*a*) the combustion air, (*b*) the gas in the burner, and (*c*) the fresh gas. For combustion on a grate, *a* has given the best result, but when firing with gases, *b* and more often *c* (as sometimes ignition in the former case is difficult) were the most successful. Experiments are described in detail; the possible savings with different gases with and without preheated air as compared with those with no circulation of the waste gases are shown in the following table (savings are given in per cent):

Temperature of circulated waste gas (°C.)	Producer gas*	Water gas	City gas	Coke-oven gas	Natural gas
		Air temperature 20°C.			
200	0.9	2.9	2.9	1.9	2.4
400	1.7	7.0	6.8	6.5	6.0
600	3.1	12.4	12.0	11.1	10.6
800	4.9	19.2	18.8	17.6	17.0
1000	8.0	28.9	28.5	26.1	26.0
		Air temperature 200°C.			
200	9.97	7.9	8.5	7.3	8.6
400	12.0	12.4	12.8	11.7	12.5
600	14.65	17.8	18.2	17.4	17.6
800	18.4	25.1	25.5	24.2	24.2
1000	24.1	34.7	35.0	32.8	33.5
		Air temperature 400°C.			
200	18.85	13.4	14.1	12.9	14.9
400	21.5	17.65	18.5	17.8	19.0
600	25.0	23.4	24.2	23.8	24.3
800	29.7	30.9	31.5	30.6	31.2
1000	36.8	40.2	41.0	39.6	40.5

* Producer gas preheated to temperature of preheated air.

The gas was, in all cases, burned with the theoretical amount of air with which the highest economy was obtained. If an excess of air is indispensable, the saving will be less but still large enough to apply this method in many cases. M.H.

Combustion control. M. J. BOHO. *Steel*, **105** [11] 42, 45 (1939).—A new method permits automatic firing and air-ratio control of either or both of two fuels. It eliminates losses from operating coke plants to supply gas for finishing operations. Control permits instant change-over from gas to oil or tar. H.E.S.

Gas firing. J. KÖRTING. *Gas- & Wasserfach*, **83** [12] 133–39; [13] 148–50 (1940).—K. discusses the principles of the design and installation of gas burners from the viewpoint of large and small heat requirements. He explains the calculation of nozzle sections, necessary amount of air, and velocity of combustion together with the mixing arrangements for gas and air and gives the theory of combustion, taking into consideration the heat transmission from flame to furnace wall and goods. For very high temperature flames and where large quantities of gas are required, such as in open-hearth and glassmelting furnaces, only brickwork can be used around the burner. Where gas passes through the burner with very high velocities and the sections are therefore small, metallic burners or metallic nozzles in a brick air port have been used successfully. Eight references. M.H.

Gas washing. A. J. BOYNTON. *Steel*, **105** [23] 50–53 (1939).—A recently developed system of wet gas washing provides a practical and inexpensive method of completely cleaning blast-furnace gas. The system involves stationary disintegration and is used with a parallel spiral-passage moisture eliminator. H.E.S.

Heat transfer by radiation. W. HEINZE AND S. WAGENER. *Z. tech. Physik*, **18**, 75–86 (1937); *Jour. Soc. Glass Tech.*, **24** [101] 12A (1940).—A method of calculation is given for determining the temperature of a body in a system of *n* bodies exposed to thermal radiation. The principle is illustrated by an example which shows an agreement of 2% between observed and calculated values.

Heat transfer by radiation of flue gas. TORSTEN WIDELL. *Iva*, **1939**, pp. 14–28; abstracted in *Chem. Zentr.*, **1940, II**, 104.—Equations for the heat transferred by a gas through radiation on a wall and the correction of the radiation factor were worked out; diagrams were drawn for the partial pressure of the ingredients of the gas mixture, the radiation factors for CO_2 and water vapor, the correction of the simultaneous presence of CO_2 and water vapor, and the determination of the heat transfer figure. M.V.C.

Pyrometric rings for measuring kiln heat treatment. LOWELL H. MILLIGAN. *Bull. Amer. Ceram. Soc.*, **19** [7] 247–51 (1940).

Too many brick set in kiln defeat benefit of long flame. J. G. SEANOR. *Bull. Amer. Ceram. Soc.*, **19** [7] 245–47 (1940).

Weatherproofing and maintenance of kilns. L. A. KIMBERLING. *Brick & Clay Record*, **94** [6] 27–28 (1939).—K. discusses the maintenance of kiln bands, bottoms, and crowns. A detailed method of weatherproofing the crowns is described. J.J.H.

SEPARATE PUBLICATION

Developments in Coal Research and Technology in 1937 and 1938. ARNO C. FIELDNER. *U. S. Bur. Mines Tech. Paper*, No. 613, 95 pp. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price 10¢. See "Annual . . .," *Ceram. Abs.*, **17** [6] 229 (1938). R.A.H.

PATENTS

Producing high temperature heating resistors. REINHOLD REICHMANN (Westinghouse Electric & Mfg. Co.). U. S. 2,208,342, July 16, 1940 (May 16, 1939).—A heating unit comprises a substantially gas-tight ceramic tubular member having a bore and a refractory metal core (which recrystallizes when heated accompanied by increased volume) swelled in the bore of the tubular member by heating to fill the bore of the member for a substantial portion of its length.

Tunnel kiln ware support. W. O. PROUTY. U. S. 2,207,412, July 9, 1940 (June 1, 1937).

Geology

Bauxite of Poços de Caldas, São Paulo, and Minas Geraes. EMILIO ALVES TEIXEIRA. *Boll. Serviço fomento producção mineral, Brasil, Avulso*, No. 15 (1937); *Neues Jahrb. Mineral., Geol., Ref. III*, **1939**, 198–99; *Chem. Abs.*, **34**, 4025 (1940).—This occurrence has been formed by the weathering of nephelite rock and, as worked, contains 62% Al_2O_3. See *Ceram. Abs.*, **19** [7] 171 (1940).

Bentonite clays in U.S.S.R. N. K. SAZONOVA. *Trudy Leningrad. Krasnoznamennogo Khim.-Tech. Inst., Lab. Keram.*, **1939**, No. 7, pp. 217–44; *Khim. Referat. Zhur.*, 2

[5] 88–89 (1939); *Chem. Abs.*, **34**, 3036 (1940).—The bentonites showed the presence of crystals of montmorillonite and admixtures of feldspar and biotite. They swell 3 to 4 times as much as do the best plastic clays. Their plasticity was studied by the amount of adsorbed moisture from air saturated with water vapor. During 5 days most samples adsorbed ⅔ of the amount of moisture which corresponds to a complete adsorption. The refractoriness did not exceed 1300°. Addition of 5% bentonite lowered the refractoriness of the grog of the Chasov-Yar clay by 10° to 30°. The Oglanlin bentonites have the best plasticity, adhesion, binding power, and swelling properties. Addition of 5% bentonite to slightly plastic substances increased their plasticity and binding properties. Adding bentonite as a binding material had no appreciable effect on refractoriness.

Bonding clays and the properties of synthetic molding sands. G. H. PIPER. *Foundry Trade Jour.*, **60** [1191] 509–13 (1939).—The use of synthetic molding sands has increased rapidly during the last five years. These sands permit greater control of strength and permeability, and thus there are fewer casting defects (natural sands have frequently a high silt percentage and too low a permeability). They are suitable for mechanized sand plants and are economical in operation. H.E.S.

Clays and kaolins of the Far East. A. D. FEDOSEEV. *Ogneupory*, **7** [2–3] 184–90 (1940).—The characteristics of clay and kaolin deposits in the Far East are briefly discussed. M.V.C.

Considerations and research on silicates. UGO PANICHI. *Rend. ist. lombardo sci., Classe sci. mat. nat.*, **71**, 318–26 (1938); *Chem. Abs.*, **34**, 3610 (1940).—P. deals with the relations between chemical formula and structure, based on the reference group Si_mO_n. The experimental part comprises mineral synthesis and X-ray analysis. Acid silicates may be represented by $m(H_4SiO_4) - n(H_2O)$ or more easily by $p(SiO_2) + q(H_2O)$. A survey of 84 minerals is made, and the number of H_2O molecules is plotted against the number of SiO_2 molecules. The minerals are discussed in detail in order to show the suggested regularities.

Determination of the pH value of clay by means of the glass electrode. FRANK W. SELFRIDGE. *Rubber Age* [N. Y.], **46**, 287–88 (1940); *Chem. Abs.*, **34**, 3036 (1940).—It is difficult to obtain precise results by the usual pH methods, and a modified procedure was used. Stir 5 gm. of clay in 100 cc. of boiled distilled H_2O in a 150-cc. beaker for 1 min. with a glass rod, allow to stand for 20 min. (stirring frequently), centrifuge 50 cc. until clear, decant the clear supernatant liquid, add 5 drops of aqueous KCl (36 gm. in 100 cc. of boiled distilled H_2O), and determine the pH value. By this procedure, the pH values of dry-ground clays from South Carolina and Georgia varied from 4.40 to 5.70. Specially prepared and treated clays showed in some cases pH values of 8.0 or higher. If a centrifuge is unavailable or if the pH value is merely for determining the uniformity of clay, a procedure for determining the sorptive power of clay for K ions is useful. Stir 5 gm. of clay, 1 cc. of aqueous KCl (as above), and 100 cc. of boiled distilled H_2O with a glass rod for 1 min., transfer 40 cc. to a 50-cc. beaker, allow to settle for 20 min., and determine the pH value of the supernatant liquid.

Effect of heat on the clay minerals illite and montmorillonite. R. E. GRIM AND W. F. BRADLEY. *Jour. Amer. Ceram. Soc.*, **23** [8] 242–48 (1940).

Experiments on the thermoluminescence of some common and unusual minerals. M. A. NORTHRUP AND O. I. LEE. *Jour. Optical Soc. Amer.*, **30**, 206–23 (1940).—Some of the qualitative aspects of thermoluminescence are noted, and a list of readily available thermoluminescent minerals is given. Visual observations were made on the thermoluminescence of 112 minerals comprising 32 species. The natural color, triboluminescence, fluorescence, and phosphorescence, if any, of each are also described. Special attention was given to the fluorites, calcites, apatites, lepidolites, and feldspars. Thermoluminescence appears to be most common in nonmetallic, anhydrous, crystalline minerals. A.P.

Feldspar production higher in 1939; glass industry used large share. ANON. *Amer. Glass Rev.*, **59** [37] 11 (1940).—The output of crude feldspar in 1939 exceeded in quantity that in any year except 1937. The average value per ton ($4.39) continued the downward trend started in 1936. The total of 259,194 short tons sold by merchant mills was distributed as follows: glass industry 53%, pottery manufacture 34%, and enamel trades 11%. A.P.

Geology of chrome ore deposits. V. CECHOVIC. *Hornicky Vestnik*, **21** [40] 172–76 (1939); abstracted in *Chem. Zentr.*, **1940, I**, 189.—Chrome ore deposits, especially those in the Balkan peninsula, are discussed with regard to the matrix and accompanying rock, the form, structure, and state of the ore, the mineralogical composition of the ores and their metamorphosis, and the origin of the deposits. A bibliography is included. M.V.C.

Mineralogical structure of Yentai clay slate with regard to the preparation. MASAYOSHI WADA. *Trans. Mining & Metallurg. Alumni Assn.*, **9** [5–6] 831–39 (1939); abstracted in *Chem. Zentr.*, **1939, II**, 4052–53.—The mineralogical composition of slate containing about 14 SiO_2, 3 TiO_2, 4 Al_2O_3, 4 Fe_2O_3, and 8% FeO is similar to that of slates found in Manchukuo and North China. The diaspore and kaolinite crystals are very small and appear partially as aggregates (0.3 to 2 mm. in diaspore, and 0.3 to 1 mm. in kaolinite). Diaspore crystals are distributed in the ground mass. The aggregates can be extracted by ordinary methods of preparation. The experiments carried out on burned ore yielded 19% diaspore and kaolinite in the form of aggregate. The residue, which contains about 71 SiO_2, 87 TiO_2, and 98% Fe, is not suited for dressing by ordinary methods. M.V.C.

Norwegian clay deposits for building material. GUNNAR HOLMSEN. *Norg. Geol. Undersökelse*, No. 151, pp. 3–95 (1938); abstracted in *Chem. Zentr.*, **1938, II**, 3866.—In evaluating the suitability of building clays from the Oslo deposits, the behavior of the water in the clay as well as the grain-size composition plays an important part. The effect of electrolytes on the "flowing power" of clays pugged with water was investigated: NaOH, KOH, K_2CO_3, and, in small amounts, NaCl and KCl make the clay viscous; Na_2CO_3 makes it thinly liquid if the concentration is greater than 1/80 *N*; Na_2HPO_4 has a similar action in concentrations over 0.0025 *N*; the addition of KCN or NaCN has the opposite effect and makes the clay firm with higher concentrations. The effect of the alteration of soft clay and firm clay and the displacement of water from the clay on the origin of defects is discussed at length. M.V.C.

Physical and chemical characteristics of clays related to their working properties. C. G. HARMAN. *Brick & Clay Record*, **94** [6] 26–27 (1939).—H. discusses the effect of base exchange and related phenomena on the properties of clays. The clays saturated with H, Ba, or Ca ions are relatively open in structure and allow the rather free passage of water through the pore system. The same clay, when saturated with alkali ions, is tight grained, and water flows through the system with difficulty. The trivalent ions Al and Fe behave similarly to hydrogen ions. For a given clay, saturation with Al, Fe, or H ions puts the clay in condition for the most rapid safe drying. Clays saturated with alkali ions are very difficult to dry safely and, in the case of exceptionally plastic clays, they cannot be dried safely. Porous, lean clays can be improved by alkalis because they dry readily in any case, and the added strength is desirable. Most natural shales are essentially calcium clays with lesser amounts of other ions (H, Fe, Al, K, Na, etc.). The permeability of a natural calcium clay could be increased by exchanging the adsorbed calcium for other ions such as hydrogen, aluminum, or iron. The quantity of salts required for a typical shale depends upon its base-exchange capacity and its content of soluble salts, but it is usually about 0.5%. The dry strength of clays can be modified by additions of soluble salts. In general the strengths of clays increase with their base-exchange ca-

pacities. For any given clay, the sodium clay is almost twice as strong as its hydrogen equivalent, and clays containing organic matter are stronger than similar clays free from it. It is usually impossible to make a sodium clay by adding sodium chloride. If sodium oxalate is added, calcium is precipitated and sodium is adsorbed. Sodium silicate or soap behaves in a similar manner. Clays saturated with alkali ions do not have so good working properties in the plastic state as those saturated with H, Ca, Al, etc. Sodium clays are somewhat rubbery and have a tendency to tear slightly when cut unless the clay is of a quite plastic nature or is worked very stiff. The addition of soluble salts does not change the shrinkage of clays if the water content is adjusted to bring the clays to the same stiffness in the plastic state. Plasticity, shrinkage, and the dry porosity of clays are influenced more by the water content of the plastic clay than by any other factor. The stiffer the clay when worked, the lower is the resulting drying shrinkage and porosity. Charts are included.
J.J.H.

Qualitative color test for the montmorillonite type of clay minerals. S. B. HENDRICKS AND L. T. ALEXANDER. *Jour. Amer. Soc. Agron.*, **32** [6] 455–58 (1940).—A procedure is described whereby suspensions of montmorillonite are turned red when a solution of *o*-phenylene diamine is added. Solutions of *p*-phenylene or benzidine give a blue color reaction. The color is due to an oxidation to the semiquinone form. No color reactions were obtained with halloysite, hydrated halloysite, kaolinite, ground kaolinite, glauconite, goethite, hematite, and sericite. Magnesium bentonite does not give a color reaction. Very pure montmorillonite gives only a faint test. Iron compound impurities seem essential for the color reaction; iron compounds, however, will not give a reaction unless montmorillonite is present. Nontronite gives a reaction similar to montmorillonite. Manganese dioxide, ferrous iron, and organic matter interfere. Organic matter may be destroyed by treating the sample with hydrogen peroxide.
R.K.

Sivash as a source of magnesium oxide. A. A. ALENTIEV. *Ukrain. Nauch.-Issledovatel. Inst. Ogneuporov & Kislotouporov*, No. 44, pp. 70–77 (1938).—Attempts to obtain magnesium oxide from Sivash (a series of salt lakes formed by the Black and Azov seas) are discussed. An examination of its chemical and physical properties showed that the magnesite obtained can be used successfully in magnesite refractories for metallurgical industries.
M.V.C.

Viscosities of silicate rock-forming minerals and igneous rocks. K. KANI AND K. HOSOKAWA. *Researches Electrotech. Lab.* [Tokyo], No. 391, pp. 1–105 (1936); *Mineralog. Abs.*, **7**, 449; *Chem. Abs.*, **34**, 3629 (1940).—In addition to a recapitulation of previous results, the viscosities of 13 other molten rocks (natural or artificial, including several examples) have been determined. These show that at the same temperature viscosity generally increases with the percentage of SiO_2. The effect of the addition of various oxides is also discussed.

SEPARATE PUBLICATIONS

Cadmium and Its Compounds. ANON. Ohio Dept. Health, Adult Hyg. Div., 1940, 6 pp.—General information, the industrial use, selected abstracts, and a list of references are given.
F.S.M.

Geology of Anorthosites of the Minnesota Coast of Lake Superior. FRANK F. GROUT AND GEORGE M. SCHWARTZ. *Minnesota Geol. Survey Bull.*, No. 28 (1939). 119 pp., 49 illustrations, 6 maps in pocket. Price $3. The bulletin is divided into five parts: General Features of the Region, General Geology of the Region, Detailed Description of Keweenawan Formations, Economic Geology, and Township Descriptions. Petrographic descriptions of diabases, red granites, and anorthosites are given together with new analyses of four anorthosites and five diabases. The anorthosites are usually nearly pure plagioclase rocks, in which the feldspar ranges from An_{57} to An_{85} but is dominantly labradorite (An_{65}). They occur in diabase as rounded masses varying in size from tiny fragments to masses over $^1/_4$ mile across. They are believed to represent xenoliths of solid material carried up by diabase magma. The commercial possibilities of the deposit are discussed briefly. The anorthosites usually contain about 0.5% Fe_2O_3, and this is not reduced appreciably either by magnetic separation or by flotation. An index and a bibliography are included.

PATENT

Treating calcareous materials. A. J. WEINIG (Riverside Cement Co.). U. S. 2,208,143, July 16, 1940 (Aug. 10, 1937).—In a process for the treatment of calcareous materials, wherein a plurality of constituents constituting impurities are to be removed, the steps comprise floating a plurality of impure constituents in a pulp containing calcareous material in finely divided condition by the action of cresylic acid and a hydrocarbon in a froth flotation treatment and controlling frothing by introducing an alkaline-earth soap into the pulp.

Chemistry and Physics

Behavior of iron hydroxide investigated by the emanation method: II, Influence of slight amounts of silica. HANS GÖTTE. *Z. Physik. Chem.*, **45B**, 216–28 (1940).—The structural changes of iron hydroxide are not dependent upon the precipitation velocity but are caused by the presence of silicic acid in the ammonia used for the precipitation. The silica is liberated from the glass containers and is adsorbed by the iron oxide. It increases the glowing temperature and retards the growth in the particle size after recrystallization. This action is eliminated only at temperatures of 850° to 900°C. The silicic acid also acts as a mineralizer upon the iron oxide. Both effects cause a decrease in the emanation capacity. Five curves for contaminated and pure iron oxide are included.
L.E.T.

Binary system sodium ferrite–sodium aluminite. N. A. TOROPOV AND N. A. SHISHAKOV. *Acta Physicochim. U.R.S.S.*, **11**, 277–86 (1939); *Chem. Abs.*, **34**, 3574 (1940).—Microscopic determinations of the *n* and Debye X-ray photographs show that the system $Na_2O \cdot Al_2O_3$–$Na_2O \cdot \cdot Fe_2O_3$ forms a continuous series of solid solutions. The separate components have very similar patterns, and both are thermally stable at 1500°. Data obtained for $Na_2O \cdot \cdot Al_2O_3$ agree with those of Brownmiller and Bogue (*Ceram. Abs.*, **11** [6] 388 (1932)), but those for $Na_2O \cdot Fe_2O_3$ do not agree with those of Goldsztaub (*ibid.*, **13** [3] 73 (1934)).

Determination of aluminum in Nitralloy G. 8-Hydroxyquinoline separation of aluminum from iron and chromium. L. SILVERMAN. *Chemist-Analyst*, **29** [2] 28–31 (1940).—Aluminum (1%) is separated from 1.5% chromium and 2% iron by an ammonium citrate-quinoline method.
A.P.

Method of separation and test for cadmium and other metallic ions. J. GRANT. *Chemist-Analyst*, **29** [2] 31–32 (1940).—Sodium diethyldithiocarbamate forms compounds with certain metallic ions which are soluble to varying degrees in organic solvents. Evaporation of the solvent leads to characteristic crystal structures. Copper, cadmium, cobalt, antimony, bismuth, mercury, manganese, lead, zinc, and strontium may be identified and in some cases determined.
A.P.

Phase equilibrium in the system $CaO \cdot Cr_2O_3$–$CaO \cdot \cdot Al_2O_3$. F. I. VASENIN. *Zhur. Priklad. Khim.*, **12**, 651–54 (1939).—The mixtures were sintered. Melting points were determined on cones and, optically, on rods melted in an oxygen-hydrogen flame.

$CaO \cdot Al_2O_3$ (wt. %)	$CaO \cdot Cr_2O_3$ (wt. %)	Melting point (°C.)	Refractive index n_g	n_p
100.0		1600	1.663 ± 0.004	1.643 ± 0.004
99.0	1.0	1605		
95.0	5.0	1650		
90.0	10.0	1675	Not determined	
85.0	15.0	1705	due to colored	
80.0	20.0	1770	netlike	
75.0	25.0	1833	inclusions	
70.0	30.0	1850		
50.0	50.0	2000	1.89 ± 0.02	1.87 ± 0.02
30.0	70.0		2.01 ± 0.02	1.84 ± 0.02
25.0	75.0	2040	2.08 ± 0.01	2.04 ± 0.01
20.0	80.0		2.10 ± 0.01	2.06 ± 0.01
15.0	85.0	2070	2.12 ± 0.01	2.08 ± 0.01
	100.0	2090	2.33 ± 0.02	2.18 ± 0.02

A series of solid solutions is obtained, without maxima or minima. $CaO \cdot Al_2O_3$ dissolves readily in $CaO \cdot Cr_2O_3$ in an oxidizing atmosphere. It is, however, very difficult to maintain in solution $CaO \cdot Cr_2O_3$ in $CaO \cdot Al_2O_3$ because the chromite oxidizes to yellow chromates. See "Equilibrium...," *Ceram. Abs.*, **19** [4] 100 (1940).
L.N. & E.H.W.

Quantitative determination of silicic acid. FERD. OBERHAUSER. *Anales Fac. Filos. Educac. Univ. Chile, Secc. Quim.*, **2**, 93–97 (1938); abstracted in *Chem. Zentr.*, **1940, II**, 435.—The liquid (50 cc.) containing the silicic acid was mixed with 4 cc. of a 5% ammonium molybdate solution and 5 to 6 drops of concentrated HCl and then heated to 60° to 70° for 5 min. After cooling, 10 cc. of a 0.5% alpha-naphthol solution in 10% NaOH were added, and the contents were determined colorimetrically with a standard solution. M.V.C.

Reflections on rupture. P. W. BRIDGMAN. *Jour. Applied Physics*, **9**, 517–28 (1938).—The problem of rupture is essentially a problem in stability. The difficulties of a complete mathematical discussion of the conditions of stability and rupture seem at present to be prohibitive. Any general criterion of rupture in terms of the large scale stress and strain of the ordinary elasticity theory would not be expected. When an atom's position relative to its neighbors is changed, its stability will change also. These changes may be of various types, but B. discusses especially the unusually large extensions in particular directions. Examples of ruptures on release of pressure and against the stress have been found. A.P.

Sedimentation volume and sedimentation velocity. G. G. KANDILOROW. *Kolloid-Z.*, **90** [3] 320–40 (1940).—The changes in the sedimentation volume and velocity were investigated for kaolin, finely powdered quartz, and a mixture of both in dependence on the chemical nature, valence, and concentration of certain ions (NaCl, Na_2SO_4, CaCl, $AlCl_3$, and acetic acid). Assuming that no chemical reaction takes place in these suspensions and that only a physical phenomenon exists, the kaolin particles in pure water remain united at their edges and points and show a greater adherence capacity (and thereby a greater sedimentation volume) than in suspension with various salts. In suspensions with NaCl and Na_2SO_4, smaller and denser sedimentation volumes occur. Kaolin particles have, in contrast to quartz powder, an extremely large interior surface, and, therefore, greater changes in the sedimentation volume are caused by the salts suspensions. The sedimentation volume of kaolin increases with increasing concentrations of Al_2Cl_3 solutions. With $CaCl_2$ the sedimentation volume of the kaolin suspensions is similar to that of suspensions in pure water. Diagrams and illustrations are given. L.E.T.

BOOKS

M. K. S. Units and Dimensions. G. E. M. JAUNCEY AND A. S. LANGSDORF. Macmillan Co., New York, 1940. 62 pp. Price $1.00.—The International Electrotechnical Commission (I. E. C.), meeting at Scheveningen, Brussels, in June, 1935, adopted the meter, kilogram, and second as the basic units of length, mass, and time, this action becoming effective in January, 1940. The authors' purposes are to (1) acquaint electrical engineers, physicists, and teachers and students of electrical engineering and physics with the properties of the new meter-kilogram-second (M.K.S.) system of basic units; (2) describe methods for changing from one set of basic units to another; (3) give reasons for the adoption of the ohm as the fourth basic unit (a question left open by the I.E.C. in 1935); (4) describe a proposed M.K.O.S. system of basic units; and (5) discuss the difference between magnetic flux density (B) and magnetic field strength (H). P.G.H.

PATENTS

Manufacture of silicate-clay suspensions. J. G. VAIL AND C. L. BAKER (Philadelphia Quartz Co.). U. S. 2,205,609, June 25, 1940 (Jan. 30, 1936).—In the manufacture of stable silicate-clay suspensions in strong alkali metal silicate solutions, the process comprises deflocculating clay by mixing it with a dilute aqueous solution of an alkali-metal silicate having deflocculating concentrations within the range of 0.1 to 10% by weight and adding sufficient additional silicate to produce a resulting viscosity of at least about 20 centipoises, sufficient clay being employed to produce a suspension settling not substantially more than about 50% of clear supernatant liquor in 24 hr.

Recovery of bismuth. J. O. BETTERTON AND V. E. LEBEDEFF (American Smelting and Refining Co.). U. S. 2,205,387, June 25, 1940 (Aug. 28, 1939).

Recovery of lithium salts from lithium-containing minerals. BOLIDENS GRUVAKTIEBOLAG. Brit. 521,210, May 29, 1940 (Dec. 6, 1937).

Silicate compositions and their manufacture. J. CROSFIELD & SONS, LTD. (Philadelphia Quartz Co.). Brit. 521,567, June 5, 1940 (Nov. 22, 1938).

Zirconium oxide and method of making. C. J. KINZIE AND D. S. HAKE (Titanium Alloy Mfg. Co.). U. S. 2,206,287, July 2, 1940 (Feb. 2, 1937).

General

Analysis of occupational disease claims filed during 1939. ANON. *Ohio Industrial Commission Monitor*, **13**, 55 (April, 1940).—A preliminary summary shows a marked increase over the preceding year, from 1358 to 1713. This seems to be due largely to an unusual number of claims for skin disease. Many of these are largely preventable. Lead-poisoning claims increased slightly but were less than in 1937. Prepatellar bursitis and tenosynovitis increased as did claims for poisonings from sources other than lead, such as benzol, arsenic, mercury, manganese, aniline, sulfur dioxide, and volatile petroleum products. There were 160 claims for silicosis, of which 40 were complicated by tuberculosis. The foundry industry had 53.1% of the claims and the ceramic industry 37.9%. In every case where cases of silicosis developed, high dust counts also developed. During the past year the occupational disease law was amended to include all occupational diseases. An occupational disease is defined as "a disease peculiar to a particular industrial process, trade, or occupation and to which an employee is not ordinarily subjected or exposed outside of or away from his employment." See "Origin...," *Ceram. Abs.*, **19** [5] 129 (1940). F.S.M.

Analysis of silicosis claims. ANON. *Ohio Industrial Commission Monitor*, **13**, 56 (April, 1940). F.S.M.

Arrest of toxic action of silica dust on conjunctive tissue by aluminum. A. POLICARD AND J. ROLLET. *Compt. rend. soc. Biol.*, **132** [24] 190–92 (1939).—The effects on the cornea of quartz alone and with aluminum are studied. Quartz produces a serious reaction, with edema, cellular infiltration for some weeks, and healing with opacities.

There is a very slight reaction with quartz and aluminum. See "Action...," *Ceram. Abs.*, **18** [10] 283 (1939). F.S.M.

Battelle Memorial Institute. ANON. *Bull. Amer. Ceram. Soc.*, **19** [7] 263–64 (1940).

Biomicroscopic studies of the effect of cobalt dusts (smaltite and cobaltite) on the cornea. A. POLICARD AND J. ROLLET. *Compt. rend. soc. Biol.*, **132** [24] 192–93 (1939).—A considerable time after exposure to smaltite, $CO(As)_2$, serious reactions take place. Sulfarsenide of cobalt (cobaltite) causes only a slight reaction. See "Action...," *Ceram. Abs.*, **18** [10] 283 (1939). F.S.M.

Centenary of the association of Vedrin. Career of François Kemlin. JOSEPH DE DORLODOT. *Verre & Silicates Ind.*, **11** [2] 17–19 (1940).—D. discusses the contribution of the French chemist, François Kemlin, to the chemical and glass industries, his discovery of a new process for manufacturing sulfuric acid from pyrite, and the founding of the Société de Vedrin on Jan. 1, 1940, for the purpose of exploiting the lead, pyrite, and chemicals in that region. M.V.C.

Clay shoveler's fracture. R. D. M. HALL. *Jour. Bone & Joint Surgery*, **22**, 63–80 (Jan., 1940).—The history given in these accidents is practically the same in all cases. The laborer (digging drains in clay soil) throws a shovelful of clay usually from 10 to 15 ft.; the clay sticks to the shovel and the worker feels a crack somewhere between the shoulders and is unable to continue working. H. suggests that the cause of clay shoveler's fracture is closely associated with the origins and actions of the trapezius (middle portion), the *rhomboideus major* and *minor;* the *serratus posterior superior* acts merely as an accessory to these muscles, for when the worker is in the act of throwing, his muscle is probably in full contraction, thus helping to fix the chest. The three possible mechanisms of this fracture are direct muscle violence, reflex muscle contraction, and whiplike pull transmitted through the supraspinal ligaments. Early removal of the detached fragments is doubtless the treatment of choice. F.S.M.

Evolution of pneumoconioses. M. G. PARRIQUE. *Ann. Hyg. Pub., Ind. & Sociale*, **18**, 1–16 (1940).—The identity of silicosis and tuberculosis, in the opinion of some French authors, is based entirely on pathologic-anatomical findings (*nodule absolument superposable*). P. discusses this view and presents nine case histories of silicosis (miners, stonemasons, and sandblasters) with typical X-ray pictures and without any symptoms of tuberculosis. In his opinion silicosis is a separate entity and should be listed among the compensable diseases. In France, silicosis is not recognized as a separate disease, either by scientists or by the law. F.S.M.

Fatal case of pure silicosis without tuberculosis. F. NAVILLE, R. HERRMANN, AND R. AUDEOUD. *Arch. Malad. Profess.*, **2** [4] 464–70 (1939).—A man 54 years of age had been a sandblaster for 14 years and had been continually enveloped, while at work, in a dense cloud of dust, due to imperfect ventilation in this part of the plant. There was no tuberculosis in his ancestry and he had never had a tuberculosis reaction, though he was subject to repeated and increasing attacks of bronchitis after several years at this job. In 1936, a year before his death, he received very thorough examinations in the Swiss Cantonal Hospital, to which he had been ordered after his reduced condition was fully appreciated by authorities. Details of these records afford a useful background for those of the autopsy in 1937. A massive pneumonoconiosis was present in both lungs, with cicatricial atrophy of both upper lobes and ganglionic pigmented metastases. The lungs had been so progressively and completely reduced in functional power by the invasion of mineral dusts that the density of the subsequent fibrosis finally prevented any respiratory action and retarded the operation of the heart. No tubercular trace was found in his entire body. This fact is insisted upon in the multiplicity of medical details. Certain Continental authors and notably a group of French authors have regarded silicosis as inevitably conditioned in tuberculosis, or at least, inevitably associated with it; the French schools of Lyon and Nancy have long recognized it as a separate disease entity. The authors review the mounting record of pure, uncomplicated cases of silicosis and list the extensive bibliography of the 1927 to 1937 decade. K.R.

Heat transfer in the radiant section of petroleum heaters. W. E. LOBO AND J. E. EVANS. *Trans. Amer. Inst. Chem. Engrs.*, **35** [5] 743–78 (1939).—Empirical equations for predicting heat transfer in the combustion chambers of steam boilers and petroleum heaters are reviewed, and 85 performance tests on 19 furnaces differing widely in the amount and arrangement of refractory and cold surfaces are studied. Data on operating conditions are available for furnaces with and without preheated air, with and without flue gas circulation, fired with refinery cracked gas or oil fuel, and with a wide range of variation of excess air. The data are correlated by means of a theoretical equation, and deviations are no greater than the probable errors in the test data and consistently less than those obtained by the empirical equation of Wilson, Lobo, and Hottel. For simplicity of calculation, the equation is presented in graphical form. An illustrative design problem is included. H.E.S.

High tension electric burns. C. R. EDWARDS AND H. C. BOWIE. *Amer. Jour. Surgery*, **47**, 299–311 (Feb., 1940).—Since skin next to bone offers the greatest resistance to electricity and the greater the resistance the more severe is the burn, it is a common experience to see serious burns on the hands, especially on hard, calloused hands. Electric current kills tissue once contact has been established. The higher the voltage (up to 5000 to 10,000 volts), the more definite and instantaneous is the charring of tissue. In the somewhat lower level of high-voltage current, therefore, damage to tissues not immediately manifest by desiccation or charring is frequently encountered. The current penetrates deeply through skin and underlying structures, often charring only the superficial layer of skin, but enough damage is done to the tendons and their sheaths to set up an inflammation resulting in dense adhesions between these structures. Sometimes what appears to be a superficial injury develops into a very serious and far reaching one, and the reverse is also true. If an immediate *débridement* is undertaken, the tendon sheaths and joint spaces will be opened widely; if conservative treatment is carried out, sufficient granulation will occur to seal these spaces beneath the slowly separating coagulum. When bone is attacked by high-tension current, most of the damage is done to the cortical layer. Dead bone slowly separates, and when the sequestrum has been removed, the area can soon be prepared for skin grafting. The customary classification of burns should not be applied to those due to electric currents. F.S.M.

Industrial health. ANON. *Jour. Amer. Med. Assn.*, **114**, 573–86 (Feb. 17, 1940).—This general discussion of the relationships of industrial medicine is of importance because it represents the attitude of organized medicine toward this field. The article has a wide scope, covering the general subject of industrial health, the population groups involved, the unequal character and distribution of industrial medical services, effects of occupation on health, industrial accidents, occupational diseases, ordinary illness in industry, the physician in industry, industrial hygiene, physical supervision, therapy, functions of the medical service in industry, industrial health activities in organized medicine, industrial health in the government, and industrial medical education. It is believed that the principal causes of lost time to industry are the diseases and complaints found in general practice, but the industrial physician usually only diagnoses and treats minor injuries and ailments. His opportunity in the larger field of general health protection is being grasped more fully. The inadequacy of training in industrial medicine is revealed by the fact that the average amount of time devoted to industrial hygiene in medical schools is barely in excess of 5 hr. This can hardly be remedied so long as the opportunities in the field of industrial health are so few. Little advantage has

been taken of the advanced training centers in heavily industrialized communities, showing that there is evidently small demand for this field of practice. F.S.M.

I, Lead content of human blood. II, Lead as a poison. J. N. M. CHALMERS. *Lancet*, **238**, 447–50, 462–63 (March 9, 1940).—Tompsett's method of determination was used. Blood was obtained from 20 normal people and 50 hospital cases, all with no known exposure to lead, and also from 44 factory workers with a definite lead exposure while manufacturing white lead and storage batteries. The blood of the controls showed a lead content which varied from 30 to 90 μgm. per 100 cc. with a mean of 57. The lead workers, who presented no symptoms of poisoning, had blood lead values ranging from 60 to 192 gm. per 100 cc. with a mean of 104. Augmented concentrations of lead in blood indicate increased absorption of lead but do not constitute evidence of plumbism; they are a useful estimate of the degree of exposure. Clinical findings must still continue to govern the diagnosis of lead poisoning. There is a discussion of the problem and also of the value of milk in the diet of lead workers. With a high calcium diet, there is less lead absorbed from the gut than with a low calcium intake. Since, industrially, most lead enters the body through the lungs, the calcium probably acts by helping to fix the lead in the bones and thus prevent it from circulating in the blood. Though of great value, blood studies and similar biochemical investigations must not be given too much consideration. F.S.M.

Lungs of cement workers. S. CACCURI AND L. DI-PRISCO. *Folia Med.*, **26**, 7–20 (1940).—A review is given of Italian literature on the subject which seems to give a less favorable picture of the health of cement workers than is found in other countries. Histories of seven cases are given which show silicosis in grades 1 and 2 and emphysema. Tuberculosis was not found. F.S.M.

Manufacture of fired clays (brick, tile, and pottery). A. COULHON. *Argile*, No. 197, pp. 13–21 (1939); No. 198, pp. 5–9 (1940).—C. discusses the raw products used in the manufacture of fired clay products, the formation of clays, and their characteristics and composition. M.V.C.

Mechanism of development of lead anemia: IV, Physiochemical nature of the splenic and liver substances which decrease erythrocytes. S. KIN. *Jour. Med. Coll. Keijo*, **9**, 101–107 (1939).—After injection with lead acetate, the spleen and liver seem to contain some specific chemical substances which are able to decrease the number of erythrocytes. K. attempted to determine the physiochemical nature of these substances which were obtained from the splenic and hepatic veins after injection of the lead. The anemic action of the splenic substance disappeared after heating for an hour at 100°. The substance was soluble in water, but did not dissolve in ether and alcohol; it was adsorbed easily by animal charcoal or kaolin. Its action was also retained after ultraviolet radiation for 3 hr. F.S.M.

Metabolism of nucleoproteins in lead poisoning. G. MICHETTI AND F. MOLFINO. *Rass. Med. Applicata Lavoro Ind.*, **10**, 562–82 (1939).—Original research on ten cases of lead poisoning shows that there is a pronounced tendency to uric acidemia; this becomes more acute as the poisoning tends towards chronicity. No relation was seen between the degree of uric acidemia and kidney function, and no such connection is likely to exist in cases of recent lead poisoning. F.S.M.

Nature of anthracotic foci. Experimental research. A. G. SAVELLINI. *Folia Med.*, **26**, 21–32 (1940).—S. gives a review of the literature and of the views of some French and Italian workers who are of the opinion that the greater part of the "anthracotic" pigment in the lungs is not truly anthracotic but iron of hemolytic origin. Animal experiments by S. lead to the conclusion that carbon and iron participate in the common anthracotic focus; some contain carbon and some iron only. F.S.M.

Occupational dermatoses under the Illinois Workmen's Occupational Diseases Act. H. R. FOERSTER. *Illinois Med. Jour.*, **77**, 79–85 (Jan., 1940).—After analyzing various sections of the Illinois law, F. concludes that "any skin disease may therefore legally be an occupational disease in Illinois." F.S.M.

Preventing economizer corrosion. F. J. MATTHEWS. *Brit. Clayworker*, **48** [575] 352–54 (1940).—M. discusses the causes of corrosion and gives suggestions for the maintenance of the economizer. R.A.H.

Priceless possessions. L. GREENBURG. *Nat. Safety News*, **41**, 26–27 (Jan., 1940).—There were 1843 cases of compensated eye injuries in New York State in 1938 and the cost was $1,165,000. Of these, 80% were caused by foreign matter entering the eye and could be avoided by the simple and cheap method of wearing goggles. Ventilation controls are needed for eye hazards of toxic dusts and fumes, and in the past year the Division of Industrial Hygiene has passed and approved 2000 sets of plans for such control in factories. Special goggles are needed for protection against radiant energy, and fatigue of the eyes can be lessened or eliminated by proper illumination. G. discusses these sight-saving means and methods for promoting their adoption. F.S.M.

Two fatal cases of pulmonary asbestosis. E. C. VIGLIANI. *Rass. Med. Applicata Lavoro Ind.*, **11**, 26–52 (1940).—The first of these cases concerns a woman who worked for thirty years in a factory using asbestos in the manufacture of cord. The second woman worked for seven years in an asbestos factory. Her susceptibility to colds increased while she was working and she suffered all her life from bronchitis and asthma. She died at the age of fifty, with symptoms of a lung disease, nearly thirty years after having stopped work. The autopsy showed interstitial sclerosis of the lungs and asbestosis bodies. F.S.M.

Unemployment benefits no bar to workmen's compensation. ANON. *U. S. Dept. Labor, Monthly Labor Rev.*, **50**, 670 (March, 1940).—An employee receiving unemployment benefits under the Unemployment Compensation Act is not disqualified from recovering compensation for the same period under the Workmen's Compensation Act, according to the Supreme Court of Michigan. F.S.M.

SEPARATE PUBLICATIONS

Basophilic Aggregation Test (for Lead Absorption and Lead Poisoning). ANON. Ohio Dept. Health, Adult Hyg. Div., 1940, 7 pp.—The technique and interpretation of results of the basophilic aggregation test are given in a concise form. F.S.M.

Legal Aspects of Engineering. W. C. SADLER. John Wiley & Sons, Inc., New York. 631 pp. Price $4.00.—This is a direct application of the case method to engineering problems, three hundred cases being selected after 6500 legal cases actually dealing with engineering problems were carefully analyzed. Cases dealing with compensation are of the most interest. S. gives a general discussion of the subject. Cases are given to illustrate the following points: elimination of defenses, hazardous employment, employer-employee relation, accidents arising out of and in the course of employment, proximate cause, award, dependency, and jurisdiction. F.S.M.

Manual of Industrial Health Hazards. J. B. FICKLEN. Service to Industry, West Hartford, Conn. 175 pp. Price $4.00.—F. presents methods for the evaluation of industrial hygiene exposure resulting from many dusts, vapors, and gases. The first chapter gives principles which are basic procedures for making surveys and describes sampling devices. The other chapters are given over to the materials or groups of materials which may cause industrial disease. For each substance, F. gives the occurrence and uses, certain physical properties, the clinical symptomatology it produces in man, the physiological responses of man to various concentrations, the concentrations allowable in the air of the workplace, and a simple method of estimation in air. Numerous references are given. An appendix includes useful constants, formulas, and instructions for the preparation of standard solutions.

F.S.M.

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